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The Engineer

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PUBLIC NOTICES.

Assistant Civil Engineers REQUIRED in Civil Engineer-in-Chief's Department, Admiralty, and H.M. Naval Establishments at home and abroad. Candidates must be between the ages of twenty-five and and thirty years on the 14th May, 1932; those who have served, or are serving, in the Royal Navy, Army, or Royal Air Force may deduct from their actual age any time, not exceeding three years, during which they have so served. Candidates must either (a) be Corporate Members of the Institution of Civil Engineers, or (b) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers, or taken a degree recognised by the Institution as exempting therefrom, and have reached such a stage in their professional training that it is possible for them to become Corporate Members within two years.

Those appointed will be on probation for two years, and will not be confirmed unless and until they, being Corporate Members of the Institution of Civil Engineers, have passed this period of probation to the satisfaction of the Admiralty.

Commencing salary £250 per annum plus Civil Service bonus, which at the current rate amounts to £79 per annum.

Special consideration will be given to candidates who served in H.M. Forces during the war.

No candidate will be accepted for appointment who fails to pass a strict medical examination as to his physical fitness.

Forms of application, &c., can be obtained from the CIVIL ENGINEER-IN-CHIEF, Admiralty, London, S.W. 1, and should be returned completed so as to reach that officer not later than 14th May, 1932.

Candidates will be responsible for any expenses which they may incur in attending for interview.

8371

University of Liverpool.
FACULTY OF ENGINEERING.

DEAN: PROFESSOR T. B. ABELL, O.B.E., M. Eng., R.C.N.C., Ret., M. Inst. N.A.

Prospectus and full particulars may be obtained on application to the Registrar of Courses designed for Students desiring to qualify as Mechanical, Electrical, Civil or Marine Engineers, as Naval Architects, or as Metallurgists and Metallurgical Engineers. 8384

TO CONTRACTORS.

Builth Wells U.D.C.
WATER SUPPLY.

The Builth Wells U.D.C. are prepared to receive TENDERS for the CONSTRUCTION of a STONE FILTER HOUSE, 24ft. by 11ft. and about 110 yds. of CAST IRON MAINS, 4in. and 3in. diameter, adjacent to the Council's Service Reservoir.

Copies of the form of Tender, general conditions of contract, specification, bill of quantities and drawing may be obtained on application to the Engineers, Messrs. Lewis and Lewis, 15, Victoria-street, Westminster, S.W. 1, on and after the 18th day of April, 1932. Applications must be accompanied by a deposit of £1, which will be refunded after the receipt of a bona fide Tender and the return of the drawing to the Engineers. Copies of the drawing and documents may also be seen at this office.

Tenders, which must be made on the form supplied, are to be forwarded together with a signed copy of the documents with the bill of quantities fully priced out in a sealed envelope endorsed outside "Tender for Builth Wells Waterworks." The sealed envelope is to be enclosed in an outer envelope and delivered to the Clerk, Council Offices, Builth Wells, Breconshire, on or before Monday, May 9th, 1932.

The Council do not bind themselves to accept the lowest or any Tender.

REGINALD J. OWEN,
Clerk to the Council.
Builth Wells. 8392

County Borough of Bolton.
NEW CIVIC CENTRE.

The Corporation of Bolton invite TENDERS for HEATING and VENTILATING INSTALLATIONS under one Contract for:—

(1) Sessions Hall and Police Building.
(2) Library, Museum and Art Gallery.
(3) Town Hall,

in accordance with plans and specification prepared by Messrs. Bradshaw, Gass and Hope, FF.R.I.B.A., Chartered Architects, 19, Silverwell-street, Bolton.

Persons desiring to Tender for the above work must submit their names and addresses to the undersigned, not later than the 27th day of April, 1932, together with a remittance of £5. This sum will be returnable only to those who send in a bona fide Tender and do not withdraw the same.

A copy of the plans and specification will be supplied in due course to persons who apply as above, and thereafter the 1/8in. scale building drawings and form of contract may be inspected at the offices of the Architects.

The successful contractor will be required to observe the conditions of a fair wages clause, the full terms of which will be embodied in the form of contract, and will further be required to provide two sureties, or a bank, or an insurance company, to be approved by the Corporation, to join him in a bond in a sum amounting to 10 per cent. of the amount of the Tender for the due performance and fulfilment of the contract.

The Corporation do not bind themselves to accept the lowest or any Tender.

SAMUEL PARKER,
Town Clerk.
Town Hall, Bolton,
13th April, 1932. 8409

County Borough of Newport.
TALYBONT RESERVOIR SCHEME.

The Newport Corporation invite TENDERS from contractors, skilled in the carrying out of works of a similar character, for the CONSTRUCTION of a Large IMPOUNDING RESERVOIR near Talybont, Breconshire, &c., can be seen at all reasonable times at the offices of the Engineer, Mr. W. E. Lloyd, M. Inst. C.E., Town Hall, Newport, Mon., from whom full particulars and bill of quantities can be obtained upon the production of the Borough Treasurer's receipt for £100 deposit, which will be returned upon receipt of a bona fide Tender. The Reservoir is being constructed with the aid of a grant from the Unemployment Grants Committee, and tenderers will be required to comply with the conditions laid down under the terms of the grant. Sealed Tenders, endorsed "Talybont Reservoir," must reach me not later than 10 a.m. on the 5th May, 1932. The Corporation do not bind themselves to accept the lowest or any Tender.

O. TREHARNE MORGAN,
Town Clerk.
11th April, 1932. 8387

PUBLIC NOTICES.

County Borough of Brighton.
WATERWORKS DEPARTMENT.
TO STEEL PIPE MANUFACTURERS.

The Corporation are prepared to receive TENDERS for the MANUFACTURE of about 2754 YARDS of 18in. STRAIGHT STEEL PIPES, and SPECIALS, and delivery at Kemp Town Station, Brighton (Southern Railway).

Copies of the general conditions, specification, schedule of quantities and form of Tender may be obtained upon application to the Waterworks Engineer, Mr. A. B. Cathcart, M. Inst. C.E., M.I. Mech. E., at 12, Bond-street, Brighton, and enclosing a cheque for Two Guineas, which will be refunded upon receipt of a bona fide Tender (not subsequently withdrawn) and the return of the documents. The drawings may also be inspected at the offices of the Waterworks Engineer as above.

Sealed Tenders, endorsed "Tender for 18in. Steel Pipes," and addressed to me, must be delivered at my office at the Town Hall, Brighton, by Twelve Noon on Monday, 9th May, 1932.

JAS. H. ROTHWELL,
Town Clerk.
Town Hall, Brighton,
15th April, 1932. 8398

County Borough of Brighton.
WATERWORKS DEPARTMENT.
TO MAIN-LAYING CONTRACTORS.

The Corporation are prepared to receive TENDERS for CARTING, LAYING and JOINTING about 2754 YARDS of 18in. STEEL MAINS and SPECIAL PIPES, together with a SHORT LENGTH of 12in., 9in., and 3in. CAST IRON PIPES and appurtenant work.

Copies of the general conditions, specification, schedule of quantities and form of Tender may be obtained upon application to the Waterworks Engineer, Mr. A. B. Cathcart, M. Inst. C.E., M.I. Mech. E., at 12, Bond-street, Brighton, and enclosing a cheque for Two Guineas, which will be refunded upon receipt of a bona fide Tender (not subsequently withdrawn) and the return of the documents. The drawings may also be inspected at the offices of the Waterworks Engineer as above.

Sealed Tenders, endorsed "Tender for Laying 18in. Steel Pipes," and addressed to me, must be delivered at my office at the Town Hall, Brighton, by Twelve Noon on Monday, 9th May, 1932.

JAS. H. ROTHWELL,
Town Clerk.
Town Hall, Brighton,
15th April, 1932. 8399

PUBLIC NOTICES.

County Borough of Southend-on-Sea.
TO CONTRACTORS.
"SANDBERG" STEEL TRAMWAY RAILS, BRITISH MANUFACTURE.

The Corporation are prepared to receive TENDERS for the SUPPLY and DELIVERY of 50 or alternatively 100 tons of "SANDBERG" STEEL TRAMWAY RAILS, B.S. Section No. 7.

General conditions, form of Tender and specification may be obtained on and after Thursday, 21st April, 1932, on application to Mr. Robert H. Iyer, Borough Engineer and Surveyor, on payment of a deposit of One Guinea, which will be refunded on receipt of a bona fide Tender and the return of all loaned documents.

Sealed Tenders, addressed to the undersigned and endorsed "Steel Rails," are to be delivered to this office on or before 9 a.m., Tuesday, 10th May, 1932.

The Corporation do not bind themselves to accept the lowest or any Tender.

H. J. WORWOOD,
Town Clerk.
Municipal Buildings,
Clarence-road, Southend-on-Sea.
April, 1932. 8414

Paignton Urban District Council.
MAIN DRAINAGE: CONTRACT NO. 4.
SEWAGE AND STORM WATER PUMPING PLANT.

The above Council invites TENDERS from competent Firms of Manufacturers specialising in Pumping Machinery for the SUPPLY, DELIVERY, and FIXING of an INSTALLATION comprising Vertical Four-stroke Engines, Vertical-spindle Screw Pumps, and Vertical-spindle Chokeless Pumps, at the Council's proposed Pumping Station in the Paignton Urban District.

Copies of the form of Tender, drawings, general conditions of contract and specification may be obtained and plans and sections inspected at the offices of F. W. Vanstone and Sons, Civil Engineers, 12, Victoria-street, Paignton, upon deposit of a sum of Five Pounds, which will be returned after consideration of a bona fide Tender.

The Council do not bind themselves to accept the lowest or any Tender.

Tenders, endorsed "Paignton Drainage—Contract No. 4," accompanied by scale drawings, should be delivered to the undersigned not later than Noon on Saturday, the 28th of May, 1932.

JOHN HARTLEY,
Clerk to the Council.
Town Hall, Paignton. 8394

PUBLIC NOTICES.

FOR SALE.
600 kW D.C. BELLISS G.E.C. PLANT.

The Barnes Urban District Council has FOR DISPOSAL ONE 600 kW STEAM ENGINE and DYNAMO, complete with Condenser, Air and Circulating Pumps and Switchgear.

The Engine is triple-expansion by Belliss and Morcom, and operates at 150/160 lb. superheated.

The Dynamo is by the General Electric Company, and is designed to give its output at 400-500 volts.

The Condenser, Air and Circulating Pumps are by Allen, of Bedford.

The plant is in a first-class state of repair and may be seen in operation.

C. S. DAVIDSON,
Engineer and Manager.
Electricity Works,
Mortlake, London, S.W. 14. 8388

Borough of Torquay.
APPOINTMENT OF BOROUGH ENGINEER AND SURVEYOR.

The Council invite APPLICATIONS for the POSITION of BOROUGH ENGINEER and SURVEYOR, at a salary commencing at £950 a year and rising, subject to approved service, by annual increments of £50 to a maximum of £1100 a year.

Applicants should not be more than 45 years of age and should be Members or Associate Members of the Institution of Civil Engineers or Members of the Institution of Municipal and County Engineers.

No pension or superannuation rights are attached to the office.

A form of application, with a list of duties and general conditions governing the appointment, may be obtained from the undersigned.

Canvassing, either directly or indirectly, will be deemed a disqualification.

Applications must reach the undersigned not later than May 7th, 1932.

HERBERT A. HIELD,
Town Clerk.
Town Hall, Torquay,
Dated April 12th, 1932. 8382

Egyptian Government.
APPOINTMENT OF MECHANICAL ENGINEER.

APPLICATIONS are INVITED for APPOINTMENT as MECHANICAL ENGINEER in the MINISTRY OF PUBLIC WORKS, CAIRO, for work with the Egyptian Irrigation Service in the Sudan.

Applicants must be of British nationality, between 30 and 35 years of age, preferably unmarried, and possess the following qualifications:—

Must hold a first-class Board of Trade Certificate as a Marine Engineer, have at least two years' experience at sea, and must produce certificates of satisfactory service, preferably where native labour was employed.

Must have experience of the Construction and Repair of Modern Marine and Shore Boilers in a recognised Shipbuilding or Repair Yard, other than as apprentice.

Salary £E288, plus 40 per cent. per annum (£E1 equals £1 0s. 6d. approximately).

In conformity with the Decision of the Council of Ministers dated 30th January, 1932, a stamp duty shall be deducted monthly from the salary payable according to the present contract, on the basis of the rate fixed by the aforesaid decision of the Council of Ministers.

Free furnished quarters will be provided except in Khartoum.

The appointment is subject to medical examination and subsequent approval of the Authorities in Egypt.

The selected candidate will be entitled to an allowance on transfer, either equal to one month's pay or to the actual expenses incurred for the journey if such expenses exceed the one month's pay, provided in the latter case the necessary vouchers are produced.

The expenses to be so refunded shall be limited to Railway and Steamer fares with an extra £E10 to cover other expenses, such as cost of sleeping car tickets, porterage, freight of luggage, &c. The same ruling is to be adopted in the case of the return journey after the expiration of service. However, the actual expenses shall not be refunded except when such journey is made to the country where recruiting originally took place, otherwise an allowance equal to one month's pay shall only be granted.

Initial period of contract TWO years, renewable.

Third-class fares and reasonable out-of-pocket expenses will be paid to applicants who are requested to attend for interview and/or medical examination.

Application and specimen contract forms may be obtained from the:

CHIEF INSPECTING ENGINEER,
Egyptian Government,
41, Tothill-street, London, S.W. 1.,

to whom they should be returned with full particulars as to education, qualifications, previous experience, personal references and copies (NOT ORIGINALS) of certificates or testimonials which will not be returned.

Envelopes to be inscribed MECHANICAL ENGINEER. 8383

SITUATIONS OPEN.

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

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For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge and co-operation is asked for.

WANTED, MECHANICAL ENGINEER, with Costing, Estimating, Administrative and Commercial experience by makers of Pumps, Pumping Machinery. Salary, training, and experience must be stated. Progressive ability would lead to directorship which money could not buy.—Address, 8408, The Engineer Office. 8408 A

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The Engineer

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This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER in each calendar month.

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Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published annually in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

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Apply, giving fullest information of experience, stating age and salary required, to ENGINEER, c/o Wykes and Co., Chartered Accountants, 24, Friar-lane, Leicester. None but first-class men need apply. 8367 A

CHIEF ENGINEER REQUIRED for Large Mining and Smelting Company abroad, having its own hydro-electric station, steam turbines and Diesels, complete mine equipment, ore reduction mill gravity and flotation, lead smelter and refinery, large machine locomotive wagon shops and foundry. Applicants must be particularly strong on mechanical rather than electrical side. Previous experience similar capacity and ability administer departmental staff absolutely essential. Salary about £1200 per annum. —Write in first instance, Box T.260, Willings, 135, Moorgate, London, E.C. 2. 8413 A

ENGINEER, Well Up in the Construction of Terra Cotta Hollow Block Flooring and Partitions, REQUIRED to TAKE CHARGE of a CONTRACT BUSINESS for the Supply and Fixing of these materials.

Must have first-class qualifications and experience.

Address, 8411, The Engineer Office. 8411 A

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SITUATIONS WANTED.

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Automatic Couplings.

THE labour representatives at the International Labour Bureau at Geneva have always been insistent in their demands for arrangements to equip the rolling stock of all the European railways with automatic couplings. At the quarterly meeting of the Bureau last week they again urged that an immediate decision should be come to so as to provide work for the unemployed. They wanted the International Railway Union to bear the cost of testing devices, which the Union declared it was unable to do, stating that it was obliged to restrict its attention to apparatus presented by members and previously tested by them. So far, only one country had asked the Union to examine a coupling, and had not proceeded with the matter further because the cost of the experiments was too high. The problem is complicated by the necessity of adapting new couplings to existing coaches without extensive alterations to the frames and without involving too much cost in replacing the couplings already in use. A German employers' delegate declared that this result had been attained by a new automatic coupling, experimented with on the Reichsbahn, which, he said, had entirely solved the problem, and the labour members thereupon requested the International Railway Union to examine the device and ascertain whether any of its members would be disposed to carry out tests with it, while, in view of the financial difficulties in the way of experimenting with and selecting a standard automatic coupling, it was suggested that some of the Governments should be asked to contribute to a fund for the creation of a research committee, which would be under the control of the International Railway Union, and the tests would be carried out under the auspices of the Union, the Labour Bureau, Government representatives, and of others concerned in the equipment of railways with automatic couplings.

Road and Rail.

THE Minister of Transport, Mr. P. J. Pybus, met representatives from associations of local authorities on April 1st, in order to hear their views with regard to the constitution of the proposed Conference on Rail and Road Transport, and its terms of reference. After considering the views expressed at this meeting as to the somewhat wide nature of the terms of reference as originally drafted, and after consulting the members of the Conference, the Minister has decided to revise the opening clause of the reference so as to define the scope of these inquiries more closely and to incorporate the assurance which he had already given as to the position of highway authorities and other interests concerned. The revised terms of reference will now read as follows:—"From the point of view of establishing what would be a fair basis of competition and division of function between rail and road transport of goods, and for the purpose of furnishing advice and information upon which the Minister of Transport will invite the views of the highway authorities and other interests concerned, to consider the facts relating to the incidence of highway costs in relation to the contributions of the different classes of mechanically propelled vehicles; to consider the nature and extent of the regulation, which, in view of modern economic developments, should be applied to goods transport by road and by rail; and, in the light of any conclusions reached under these heads, to make such further recommendations as they are able to frame designed to assist the two sides of the industry to carry out their functions under equitable conditions, which adequately safeguard the interests of trade and industry, and to report by the end of July." Sir Arthur Salter, K.C.B., has been appointed by the Minister as the Independent Chairman of the Conference.

Callender's Jubilee.

ON Tuesday last Callender's Cable and Construction Company, which began operations as Callender's Bitumen, Telegraph and Waterproof Company on April 12th, 1882, celebrated its jubilee. The origin of the company can, however, be taken back to the 'seventies, when William Ormiston Callender, having acquired an interest in part of the Trinidad Lake, founded, with his two sons, Thomas Octavius (now Sir Tom) and William Marshall, the business of Callender and Son in 1877 for the furtherance of the use of Trinidad bitumen. The firm was instrumental in bringing into practical use in this country the asphalt deposits of the well-known lake. In those early days the only outlet for insulated wires was in connection with the electric telegraph, but when Swan and Edison brought the incandescent electric lamp into use it became evident that a new field was open to the firm. Fourteen years of active trading saw such an extension of the company's business that an enlargement and reorganisation became necessary, and on July 24th, 1896, Callender's Cable and Construction Company, Ltd., was registered with a capital of £100,000. Mr. Tom Callender was appointed manager of Callender's Bitumen, Telegraph and Waterproof Company at its inception in 1882, and occupied that position until the reorganisation and registration of Callender's Cable and Construction Company in 1896, when he was appointed to the board as managing director, a position which he still holds. Valuable assistance was given him in the early days by his brother William, and subsequently by his brother James, both of whom are now dead. In 1901 the issued share capital was £375,000, in 1920 £1,300,000, and to-day £1,916,000, excluding debentures and large undistributed reserves.

World Shipbuilding Returns.

THE quarterly statistics issued by Lloyd's Register of Shipping for vessels under construction at the end of March last show that at that date a total of 372,973 tons of shipping were under construction in the shipyards of Great Britain and Ireland. This total, it is remarked, is the lowest since December, 1886, and is 320,841 tons less than the tonnage under construction for the same period last year. About 30 per cent. of the tonnage is for sale or for registering abroad. The total tonnage under construction abroad is 924,990 tons, the leading countries in order of amount being:—America, 206,703 tons; Italy, 181,821 tons; France, 156,760 tons; Germany, 103,885 tons; and Sweden, 98,301 tons. The total world tonnage under construction at the end of March amounted to 1,297,963 tons, of which 28·7 per cent. is being built in Great Britain and Ireland and 71·3 per cent. abroad. Oil tankers tonnage, which is 23·3 per cent. of the steam and motor tonnage now being built in the world, includes thirty-nine vessels of 302,172 tons. Of these ships, thirty-four are motor vessels, but five of the ten oil tankers under construction in Great Britain and Ireland are steam propelled. In the period under review the steam tonnage under construction in Great Britain and Ireland exceeded the motor ship tonnage, while abroad the tonnages for steamships and motor ships were approximately the same. In a table of marine engines under construction or being fitted on board, it is shown that there is a total of about 1,050,000 H.P. of steam engines and 143,924 H.P. of oil engines, aggregating 314 sets. Of these, 91 sets are under construction in Great Britain and Ireland, and include 70 reciprocating steam engines, five turbines, and 16 oil engines.

Recent Destroyer Launches.

WITHIN the last week no less than three destroyers, constructed to Admiralty designs under the 1930–1931 Estimates, have been safely floated. On Thursday of last week, April 7th, H.M. destroyer "Defender" was launched at Vickers-Armstrongs' Naval Construction Yard, Barrow-in-Furness the naming ceremony being performed by Lady Eyres Monsell, the wife of the First Lord of the Admiralty. It was intended to launch the sister ship, H.M. Destroyer "Diamond," after the "Defender," but owing to the very high wind it was not considered safe to do so, and the launch was therefore postponed until the following day, when the naming ceremony was performed by Miss Callander, the daughter of Mr. James Callander the general manager of Vickers-Armstrongs, Ltd., at Barrow. At the Woolston yard of John I. Thornycroft and Co., Ltd., Southampton, the destroyer H.M.S. "Daring" was launched on Thursday, April 7th, the naming ceremony being performed by Mrs. Thornycroft, the wife of Lieut.-Commander J. W. Thornycroft, R.N. (Ret.), one of the directors of the firm. This ship is the third "Daring" constructed by the firm for the Admiralty. All the destroyers of the "Defender" class above referred to are generally similar to those of the "Acasta" class, from which they only differ in matters of detail. They have a length of about 315ft., a displacement of about 1390 tons, and a speed of about 36 knots. The propelling machinery comprises a twin-screw arrangement of geared turbines, steam being supplied by three Admiralty pattern oil-fired water-tube boilers, and the machinery output is about 36,000 S.H.P. The main armament includes four 4·7in. guns, some lighter guns, and eight 21in. torpedo tubes on quadruple mounts.

Fellows of the Imperial College.

ON Monday last a very pleasant function took place in the Refectory of the Imperial College of Science and Technology. After many years of existence, both in a divided and a united state, that amalgamation of technical and scientific schools which now constitutes the Imperial College thought that the moment had come when honour might be done to distinguished men who have served it and to itself by the election of "Fellows." Acting on this decision, the following nine gentlemen were elected and the function on Monday last was a dinner given in their honour. Their names are:—Charles Vernon Boys, William Frecheville, Ralph Freeman, Sir Thomas Holland, Herbert Alfred Humphrey, Richard D. Oldham, Sir William Pope, James Whitehead, and Sir Herbert Wright. All save Mr. Oldham, detained by illness, were present. The chair was occupied by Lord Buckmaster, apparently quite recovered from his accident, who proposed by name the toast of all the Fellows in a speech remarkable alike for its wit and its ingenuity. Responses were made by Professor C. V. Boys, an Associate of the Royal School of Mines; by Sir Thomas Holland, an Associate of the Royal College of Science and until recently Rector of the Imperial College; and by Professor Sir William Pope, a Fellow of the City and Guilds Institute, now Professor of Chemistry at Cambridge University. The first two speakers "reminisced," as befitted the occasion, Professor Boys about his early experience and those with whom he had come into contact; and Sir Thomas about the men who have made the Royal School of Mines famous throughout the world. The hour was late by the time their tales were told, and Sir William Pope contented himself with a few words of acknowledgment of the honour which had been done to him, and with a suggestion that was fitting enough in that "tiled" company but too delicate to retail. The dinner was a great success, and we anticipate that it will become a traditional event in the calendar of the College.

Imported Steel.

IN a letter to *The Times*, Mr. K. D. Mackenzie, of F. Braby and Co., Ltd.; Mr. D. C. Jennings, of Burnell and Co., Ltd.; and Mr. H. Spence Thomas, of the Melingriffith Company, Ltd., representing the independent sheet, galvanised and tin-plate makers of Scotland, England and Wales, call attention to recent rumours to the effect that the Imports Advisory Committee will impose something like a 33⅓ per cent. duty on imported steel. These rumours, the signatories say, are to be viewed with the deepest and gravest concern. For many years past British sheet rollers and a large percentage of the independent tin-plate rollers have utilised the cheapest raw material, namely, basic Bessemer bars, which has enabled them to hold the export markets, with the result that employment in the finishing industry in this country is ten times more than in the steel-producing industry. If cheap material is to be denied to the British industry, then the finishing trade will be certainly developed by other nations which may have direct access to it. The time has now come, the signatories feel, to form a National Federation of Steel Consumers, advancing the views of its members in the same way as the National Federation of Steel Producers has done in the past. The nucleus of such a federation already exists in the co-operation of the interests above named. The signatories further point out that the increasing pressure of world competition has rendered more necessary than ever uninterrupted access to cheap sources of supply. The repercussions of a tariff, it is said, whilst favourable to the open-hearth branches of the steel industry, would be disastrous to the export trade of the finishing branches. Until such time as the British steel manufacturers are in a position to supply Thomas bars at an economic level, no additional duty, it is felt, should be imposed on a material which is essential to the finishing industry.

Shipyard Wages and Working Conditions.

A JOINT conference of the executive committee of shipyard trades unions and a special committee of the Shipbuilding Employers' Federation was held in London on Wednesday afternoon last, April 13th, in order to give further consideration to the proposals put forward by the Shipbuilding Employers' Federation for the revision of certain agreements which have been found to hamper the competitive powers of the industry. These proposals include the question of allowances, the removal of restrictions on the introduction of machinery, and the interchangeability of labour. They were referred to in a Journal note of March 25th last, recording the last joint conference, which took place on Monday, March 21st. On Wednesday last the trades unions' committee and the special committee of the Shipbuilding Employers' Federation joined in a full and frank discussion, in the course of which the further information desired by the unions regarding the scope of the employers' proposals was given. The meeting was adjourned for the consideration of these explanations, and we understand that still further information may probably be asked for before it is decided to call a full conference of the trades unions concerned.

Board of Trade Returns.

THE Board of Trade returns for March show that the reduction in imports and the increase in exports has reduced the adverse trade balance from £34,738,968 in February, to £24,499,038 in March, which is the smallest adverse trade balance for any month since July, 1929, and the second smallest since August, 1927. The British imports in March were £61,119,414, a figure which is £9,083,156 less than for February, and £9,482,171 less than that for March last year. Imports of manufactured goods were £7,117,844 less than in the preceding month and £9,243,265 less than in the same month of last year. The total British exports were valued at £31,196,299, or £1,184,747 more than in February, though £2,793,192 less than in March last year. The exports were helped by a further expansion in the cotton industry shipments, but the figures for the heavy industries and for coal do not compare favourably with those for March, 1931. The decline in imports was expected after the great landing of goods in this country before the general tariff came into force.

SYDNEY HARBOUR BRIDGE—PORTAL END OF SPAN AND DECK

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(For description see opposite page.)

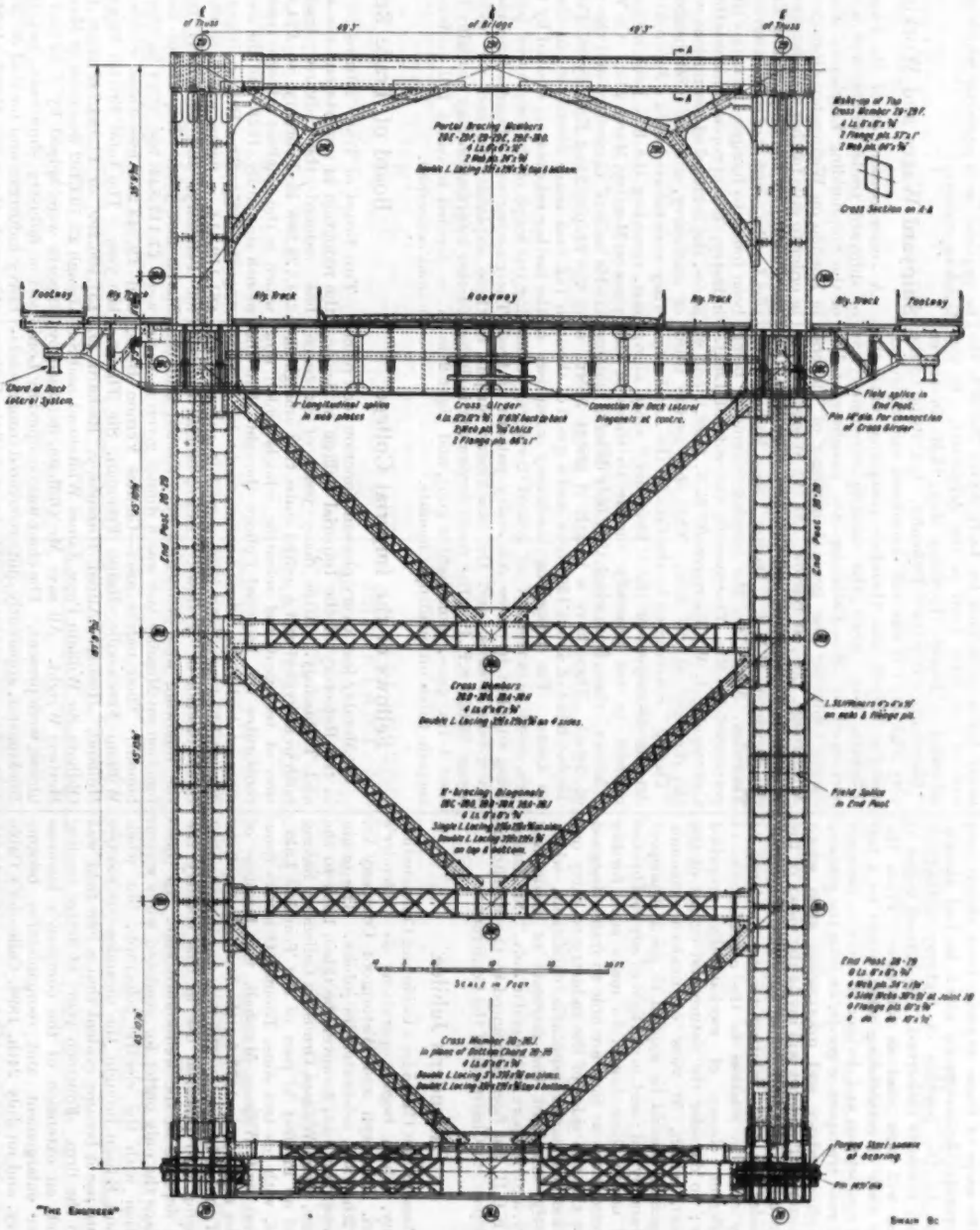

FIG. 25—PORTAL, END POSTS AND END POST BRACING

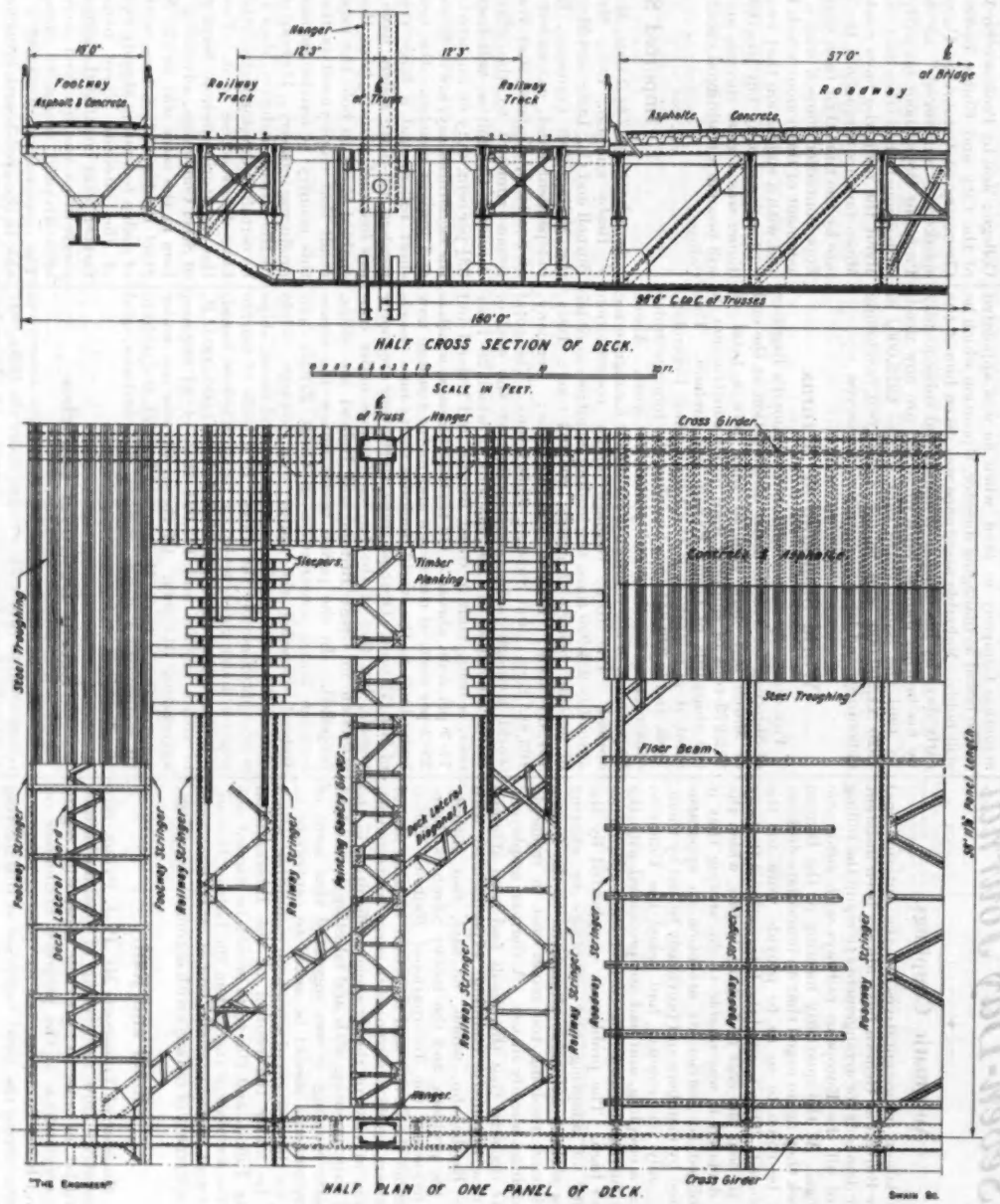

FIG. 26—SECTION AND PLAN OF ARCH SPAN DECK

Sydney Harbour Bridge.

No. V.*

THE MAIN ARCH SPAN.

Lateral Bracing.—Between the upper chords of the arch span trusses there is a complete system of transverse bracing, consisting of cross members connecting opposite panel points and diagonal members intersecting in pairs between the cross members. The cross members—see Fig. 22 *ante*—each consist of four angles laced together and connected at the ends by tie plates. These cross members have on the sides. The K bracing at the top also receives and transmits the reactions from the lateral bracing system of the deck.

The lower chords are provided with a similar system of lateral bracing except in the panel 22–20 at each side, where, as previously remarked, the lateral bracing has to be omitted to provide the head room for the traffic using the bridge. In this panel a girder similar in design to the cross members of the lateral bracing system connects the chords at a level just beneath the deck structure—see Fig. 15 in last week's Supplement. This girder is braced diagonally to the chords and to the adjacent cross member 22–22 of the lateral bracing. All the cross members

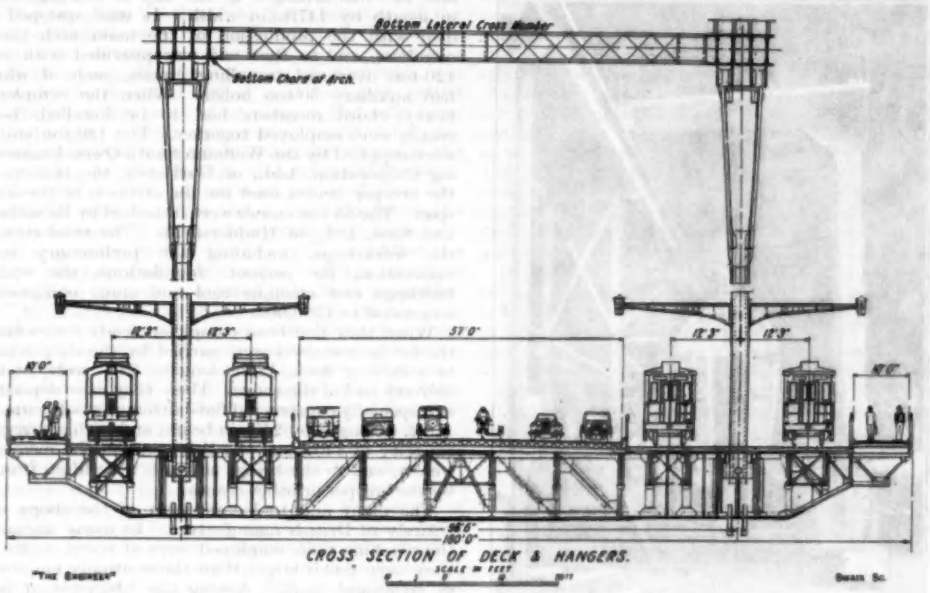

FIG. 27—GENERAL CROSS SECTION OF ARCH SPAN DECK

a depth—uniform throughout their length—equal to the depth of the chord, namely, 3ft. 4in. The diagonal members, each of which has a length exceeding 100ft., are similar in construction to the cross members, except that in depth they increase from the chord depth at their ends to 6ft. 6in. at their centres. At the points of intersection the top and bottom and side lacing of each pair of diagonals is replaced by plating in the manner illustrated in Fig. 19 of the Supplement published with last week's issue. One diagonal of each pair was erected as a single piece. The other diagonal was thereafter erected in two pieces, which were connected to the first by means of gusset plates.

The reactions from the lateral bracing system of the upper chords are carried to the tops of the end posts, whence they are transmitted down to the main bearings through the portal frame and a system of K bracing between the end posts—see Fig. 25. The top cross member of the portal frame is rhomboidal in cross section, and is composed of four angles at the corners united by two flange plates and two web plates. It is braced by members composed of four angles united by two web plates and double laced on the top and bottom. The cross and diagonal members of the K bracing between the end posts are composed of four angles laced top and bottom and of the lower chord lateral bracing have the same depth as the chords at the points at which they are connected thereto; that is to say, they vary in depth from 4ft. at the centre to 8ft. 3in. at the ends of the chords. The diagonals are also of the same depth as the chords at all points at which the chords are 6ft. 6in. or more in depth. Where the chords are of less than that depth the diagonals are increased to 6ft. 6in. at the centre of their lengths, as throughout the lateral bracing of the upper chords. Between panel point 22 and the main bearings, the lateral diagonals have laced sides and plated top and bottom flanges instead of being laced on all four faces. This construction is adopted to allow for the wind force on the deck, which is transmitted into the lateral bracing of the lower chords at panel point 22.

Deck Structure.—Between panel points 20 north and 20 south, the deck structure is supported on cross girders suspended on pin joints at the ends of the hangers attached to the lower chord joints—see Figs. 26 and 27. Beyond these two points the cross girders are attached by pins to the vertical posts of the main trusses. From each end, the deck rises towards the centre of the bridge with a 1 in 40 gradient. Over the central 600ft. of the span these slopes are joined by a flat parabolic curve. In order to simplify the connection of the deck stringers with the cross girders, the cross girders are set normal to the plane of the deck. The pins supporting the cross girders are 14in. in diameter and are placed horizontally and longitudinally in the hanger ends. As a consequence, they pass through the cross girders at an inclination—and not always at the same inclination—to the web surface.

The cross girders carrying the deck structure are of box section with the flange angles turned inwards, except for a short length near the pin connections to the hangers. Beneath the railway tracks the girders are plated. Beneath the roadway they are of lattice construction, with the bracing disposed to correspond

FIG. 30—ROADWAY BEING SURFACED

with the position of the deck stringers. The sleepers and rails are supported on stringers which are braced together in pairs. Between the inner hand rail of the footway and the outer hand rail of the roadway, the deck is floored with timber planking. The cross girders of the three panels at each shore end are connected, as already noted, not to hangers, but directly to the posts of the arch trusses. These cross girders are plated on the webs and flanges, and are otherwise of a modified design.

The surface of the roadway—see Fig. 30—is of asphalt on coke concrete, and is supported on pressed steel troughing lying on transverse steel joists, which are bent to the camber of the road. The cambered joists are carried on six plate girder stringers, spaced 11ft. 5½in. apart. The footways are carried on latticed steel parapet stringers lying on the top flanges of the cross girders. The footway surface is of asphalt and concrete on steel troughing, and is supported on cross beams of channel section. Over the full length of the suspended portion of the deck, latticed girder stringers of box section are attached between the cross girders in the plane of the arch trusses. These stringers serve to support runways for travellers employed for the inspection and painting of the underside of the deck.

FIG. 28—EXTERIOR OF "HEAVY" SHOP, MILSONS POINT

FIG. 29—INTERIOR OF "HEAVY" SHOP

* No. IV. appeared April 8th.

The deck structure is braced laterally in accordance with the arrangement shown in the lower plan in Fig. 3 of our first article—March 18th. In effect, the lateral bracing system constitutes an independent horizontal girder measuring 148ft. 9½in. from chord to chord. The chords are 2ft. 6in. deep and are formed of four angles laced together. They are attached to the ends of the deck cross girders and run longitudinally beneath the centre lines of the footways. The diagonal members of the bracing system are of the same section as the chords and are slung beneath the railway and roadway stringers. Each diagonal, it will be observed, runs from one end of a cross girder through the lattice work at the centre of the adjacent cross girder to the end of the succeeding girder. In the shore panels, the cross girders of which are plated throughout, the diagonal members of the deck bracing system, are connected to the webs of the cross girders, and are not continuous through them.

At panel point 14 North, an expansion joint capable of allowing a total movement of 11in. is provided across the full width of the deck. The deck lateral bracing at this point is articulated, the lateral reactions being transmitted through a sliding joint below the expansion joint in the deck. Expansion joints are also provided in the deck at the end posts. These joints can accommodate a relative movement up to 8in. in amount between the deck of the arch structure and the deck of the pylons. In the roadway the expansion joints are composed of a series of interlocking steel bars attached to the alternate sides of the gaps. In the footway the joints are covered by sliding steel plates. Expansion joints are also provided in the railway tracks.

Hangers.—The hangers vary in length from 20ft. at panel point 20, to 190ft. at the centre of the span. For details of their design reference may be made to Fig. 18 in the Supplement published with last week's issue. The hangers are built up of four angles united on two sides by plates and on the other two sides by single lacing bars. At the top this structure is changed to one composed of eight angles arranged in pairs back to back, and set at a small inclination to the vertical in the transverse plane. These eight angles connect the main portion of the hanger to the diaphragms between the main gussets of the chord members. The lower end of the hanger passes between the webs of the plated portion of the cross girder, the angles of which are turned outwards at the point of connection to provide the required passage for the hangers. Pins 14in. in diameter connect the hanger ends to the cross girder webs. The employment of pins at this point permitted the cross girders to be connected very rapidly to the hangers during the erection process and at the same time reduced the bending of the hangers caused by the deflection of the cross girders under load.

Maintenance Arrangements.—Access to all parts of the arch structure is provided by means of a system of steel stairways and footways. There is one such footway along the full length of the top surface of both the upper and the lower chords. At the portals there is a transverse footway on the top member connecting the end posts and at the centre of the arch there is a cross gangway between the two lower chords and also between the two upper chords. On the diagonals in the third panels from the shore and also at the centre of the arch steel stairways are provided to give communication between the two chords. On the shore side of every panel point covered manholes in the chord members give access to the interior of the chord compartments.

The facilities provided for the painting of the trusses and hangers above the level of the deck consist of four electrically operated travelling derrick cranes mounted to run on the upper chords. Access to the underside of the deck is secured by means of a gantry 20ft. wide and the full width of the deck in length. This gantry is carried on the runways, which, as noted above, are arranged beneath the deck in the plane of the arch trusses, and is propelled by means of a 5 H.P. motor. On the shoreward sides of panel points 22 North and 22 South, this gantry ceases to be available, because of the extension of the lower chords and their lateral bracing beneath the line of the deck. At each end of the bridge the gantry is replaced by three smaller gantries, one dealing with the parts between the trusses and two with the parts outside them. On the approach spans gantries somewhat similar to that on the central portion of the arch span, but hand-operated, are provided. These gantries are fitted with special tackle by means of which they can be lowered and raised to pass the braced cross girders obstructing their longitudinal movement at intervals of 30ft.

FIG. 33—RIVETING GANTRY IN "LIGHT" SHOP

MANUFACTURE OF THE STEELWORK.

In accordance with the terms of the contract, the fabrication of the steelwork for the bridge was undertaken in New South Wales. For the erection of the necessary workshops the Government allocated to Messrs. Dorman, Long a site on the North Shore of the Harbour close to Milsons Point. This site was originally too narrow for the intended purpose and was enlarged by the blasting and removal of 55,000 cubic yards of rock on the landward side. The rock removed was used for levelling and reclaiming the water front. On this enlarged site there were erected workshops covering an area of 1200ft. by 150ft. A timber wharf 250ft. long by 50ft. wide was built close to the shops, and was equipped with two 10-ton travelling cranes for unloading the raw material received from England or from the Australian suppliers. A stockyard 60ft. wide by 400ft. long was formed between the wharf and the workshops and was equipped with two semi-Goliath cranes.

The workshops were arranged in two sections, a "light" and a "heavy" shop. The light shop was laid out in two parallel bays, each 500ft. in length by 65ft. wide, with a transverse bay 187ft. long by 70ft. wide at one end. Four 25-ton cranes served the two parallel bays and a crane with two 5-ton crabs, the transverse bay. On an upper storey extending over part of the light shop, a template loft with a floor measuring 200ft. by 130ft. was provided. The light shop was devoted to the complete manufacture of the numerous lighter members and girders, and also to the preliminary stages in the production of the parts of the main chord members before they were finally assembled. The weight of the pieces handled was limited to 25 tons. The heavy shop—see Figs. 28 and 29—was arranged in one bay measuring 500ft. in length by 147ft. in width. It was equipped to deal with the production of the main arch chord members, and to that end was provided with two 120-ton overhead travelling cranes, each of which had auxiliary 50-ton hoists. When the completed heavy chord members had to be handled, both cranes were employed together. The 120-ton cranes were supplied by the Wellman Smith Owen Engineering Corporation, Ltd., of Darlaston, the makers of the creeper cranes used for the erection of the arch span. The 25-ton cranes were furnished by Broadbent and Sons, Ltd., of Huddersfield. The total cost of the workshops, including the preliminary rock excavation, the concrete foundations, the wharf, buildings and machine tool and crane equipment, amounted to £300,000.

When they had been completed ready for erection the bridge members were carried by the shop cranes to a loading dock, 125ft. long by 28ft. wide, at the delivery end of the shops. There they were deposited in a specially constructed flat-bottomed steel pontoon, 110ft. in length by 24ft. in beam, and with a carrying capacity of 140 tons. In this pontoon the members were towed to the bridge site and were lifted from it by the creeper or other cranes.

The plant and tool equipment of the shops was entirely of British manufacture. In many instances the machine tools employed were of novel design or were very much larger than those usually employed in structural work. Among the machines of particular interest were a plate edge planer capable of dealing with plates up to 66ft. long and 2¼in. thick, a Scriven plate straightening machine with rolls suitable for accommodating plates up to 12ft. wide and 2¼in. thick, an angle cropping machine, and two Craig and Donald shearing machines, one for 2¼in. plates and the other for 1¼in. plates. The drilling was carried out with the aid of fifty-five high-speed fixed, travelling, and portable radial drilling machines, all of which were supplied by William Asquith, Ltd., of Halifax. One class of drilling machine, of a gantry type, travelling on a 13ft. track laid on the shop floor, deserves special mention. It consisted of two radial drillers mounted on a carriage supported on track wheels, and was capable of operating at any point of an area 12ft. wide by 150ft. long. Several such units were mounted on the one length of track, in order that simultaneous drilling might be carried out at different points on long pieces. Altogether, nine of these units were employed. Another machine of particular interest was a wall planer supplied by Hulse and Co., of Manchester. This machine, capable of dealing with a surface measuring 12ft. by 10ft., is believed to be the largest of its class ever employed on structural work. It was used for finishing to the correct length or "ending" the chord sections and other members. The most difficult operation carried out on this machine was the machining of the end of the lower chord members for attachment to the main bearings. A photograph illustrating this operation was reproduced in Fig. 23 in last week's issue. Upon the accuracy with which this machine performed its work more depended than

FIGS. 31 AND 32—MODEL OF BRIDGE MEMBER, AND ANCHORAGE ROPE TESTED TO DESTRUCTION

upon any other process in the fabrication of the arch members. The final accuracy of the completed structure was intimately connected with the accuracy of the "ending" operations. The abutting ends of the chord members had to be machined so as to make a dead true butt joint of an area in some cases as large as 11ft. wide by 8ft. 6in. deep. The joint had, in addition, to be made at a precisely determined point of the chord length and had to bring the two abutting members together at a precisely specified angle.

The whole of the shop equipment was electrically driven. Three-phase alternating current at 440 volts and 25 cycles was used for power and at 240 volts for lighting.

The templates employed in the fabrication of the bridge members were made of hardwood. Repetition parts were, as far as possible, made on the jig system; that is to say, the first part, angle or plate, was carefully marked and drilled, and was tack bolted to the repetition parts which were drilled solid from it. The holes in the members were drilled to full size in one operation, except in the case of the holes in the ends of the members for the attachment of the main gusset plates. These holes were drilled $\frac{1}{16}$in. undersize, and were reamered out to full size after the members meeting at a panel point had been preliminarily assembled in the heavy shop. After the chord members had been "ended" all the members which were to meet at a panel point were assembled for the final reamering of the holes. The inner halves of the abutting chord members were in the first place laid down and butted together at the correct relative inclination. The main gusset plates and splicing connections were then placed in position and the holes reamered out to full size by means of a portable radial drilling machine arranged to be capable of dealing with both the webs of the box section of the half member. Thereafter the outer halves of the members were superimposed on the inner halves and the reamering process was repeated. The post and diagonal sections belonging to the connection were finally placed in position between the main gussets, their correct angular setting being determined by instrument and triangulation. The reamering of the holes for these parts completed the shop assembly. All the principal members of the main arch and deck system were, for erection purposes, fitted with specially designed lifting gear and brackets, which avoided the use of rope or chain slings.

The rivet holes were all drilled $\frac{1}{32}$in. larger than the rivets. The rivet shanks were true to diameter and were parallel throughout their length. The heads were conical, but the closing tools employed were hemispherical in order that pressure should be put on the head in the direction of the rivet axis. Before the rivets were driven, their points were quenched for a distance of 1$\frac{1}{2}$in. The general size of rivet used was 1$\frac{1}{4}$in. in diameter for grips up to 9in. A small number of 1$\frac{3}{8}$in. rivets, gripping 12in., were employed. All the field connections were made by means of pneumatic riveters. Wherever possible, the connections made in the shops were effected with hydraulic plant. For many of the shop connections, however, the closed box form of the members necessitated the use of pneumatic plant. In Fig. 33 we illustrate the riveting gantry of the light shop with a Berry hydraulic riveter at work on a bridge member.

THE 1250-TON TESTING MACHINE.

It was stipulated in the specification that the contractor was to provide a 1250-ton testing machine in order that tests to destruction might be carried out on large-scale models of various members of the bridge. This machine, designed and made by W. and T. Avery, Ltd., of Birmingham, was installed at Messrs. Dorman, Long's Britannia Works in July, 1926. An illustrated description of it will be found in our issue of July 30th, 1926. It is the largest universal testing machine in this country. Tension and compression specimens up to 50ft. in length and 3ft. 9in. square in cross section and bending test specimens up to 20ft. in span, can be accommodated in it. In all three cases the full load of 1250 tons can be exerted.

Before the construction of the arch span was begun nearly forty scale models of different members or parts of members of the trusses were tested to destruction. The models were made of the largest size which the machine could break, and were tested as closely as possible under the conditions to which they would be subjected in the bridge. The largest chord members were reproduced to a scale of one-sixth, and in all cases the material employed was identical with that used for the actual full-sized member. In general, three identical models were made of each member to be tested, the reinforcement at the ends of the member and any intermediate splicing material being omitted. A fourth model of the same part with all the reinforcement, covers, and splices copied as closely as practicable, was also tested in order to determine the effect of these details upon the strength of the member. The stress and distortion readings made during the progress of the tests are stated to have borne out fully the estimated strengths of the members. In Fig. 31 we illustrate a member tested to destruction in the machine.

In addition to these tests on members of the bridge, the machine was also employed to test many parts of the erection equipment. In particular, it was used to subject the anchorage ropes and their sockets to destruction and proof load tests—see Fig. 32. Valuable information was obtained during these tests concerning the design of the sockets and the elongation of the ropes under load. The knowledge obtained regarding the elongation of the ropes under load was of especial value in that it enabled an accurate forecast to be made of the movements of the half arches as they progressed towards completion.

The 1250-ton testing machine, in charge of an expert staff, is now available to, and has already been used by, a number of firms for ordinary commercial testing.

(To be continued.)

Electrical Equipment and Mining Plant at Mount Isa Mines.

No. I.

MOUNT ISA MINES, the site of one of the largest silver, zinc, and lead ore deposits in the world, are situated in North-West Queensland, Australia, at the terminus of a railway line which runs 600 miles west from Townsville, the nearest port. Mount Isa is 1200ft. above sea level and its climate, while delightful in winter, is semi-arid in the summer, with a temperature reaching 150 deg. Fah. The district around—Figs. 1 and 2—consists of ranges of low hills and narrow valleys, through one of which runs the river Leichardt, separating "Mount Isa Town" from the mines and "Isa Mines Town," the two towns being about a mile apart.

An abstract from a progress report by a Technical Committee gives a summary of ore reserves to August, 1930. From this summary, given in the table in the next column, it will be seen that, while there is a large tonnage of high-grade ore in the deposit, the bulk of it is of comparatively low grade.

Soon after the ore bodies were discovered, some seven years ago, it was recognised that to work such a large deposit of low-grade ore economically the most up-to-date equipment, involving a large capital expenditure, would be necessary, and great credit is due to Mr. Leslie Urquhart and others for their courage in embarking upon so extensive a venture. The development work showed that, owing to their location, the newly discovered ore bodies could be worked most economically as one big mine, which would give a reduction in the shaft and transport costs as compared with that of several small mines. Accordingly the land was surveyed to fix the main haulage shaft at the most advantageous point for all bodies and with due regard to the position of the mill, smelter, and railway.

Ore Reserves to August, 1930.

Carbonate ore.	Tons.	Lead.	Zinc.	Silver.
		Per cent.	Per cent.	Ounces.
Rio Grande	200,000	15·8	—	9·2
Black Rock	120,000	22·4	—	10·6
Mount Isa	100,000	12·0	—	4·4
Black Star	3,180,000	8·0	—	3·0
Sulphide ore.				
Black Star high grade	12,779,000	8·0	9·0	4·9
Black Star low grade	11,522,000	4·8	6·6	2·6
Black Star foot wall veins	2,153,000	8·6	10·9	4·6
Rio Grande to 500ft...	500,000	15·0	4·0	15·0
Total	30,554,000			

The position finally selected was on the top of a hill above the railway sidings and sufficiently high to ensure a gravitational flow for the majority of the processes involved. Unfortunately, however, the area at the hill top was insufficient to accommodate the buildings necessary for the men and supplies, such as the charge house, drill shops, and timber shops, &c., and it was therefore decided to sink a man-and-supply shaft about 2000ft. north-west of the main haulage shaft. Haulage drives connect these two shafts and the main ore bodies at a level of about 350ft. below the collar of the man-and-supply shaft.

PUBLIC SERVICES.

The chief ore body, Black-Star-Lode, is worked mainly by "glory holes" and by caving, as described by Mr. Chas. A. Mitke in the *Engineering and Mining Journal* of December 1st, 1929. The chief problems that faced the company were those of obtaining accommodation for its *personnel*, the provision of an adequate supply of water, and a cheap power supply. The problem of housing the staff and employees has been met by the erection of houses at Mount Isa for married men and their families and dormitories for single men. The "Isa Mines" township possesses an up-to-date hospital with two doctors and a dentist, a club with a library and reading rooms, a billiard room, a dry bar, tea rooms, and a barber's shop. There are also a school and a commodity store which competes with city prices 1500 miles away. In all the houses, which are netted against flies, there is a supply of good water, and electricity for lighting. Septic tanks are provided for sanitation. Owing to the enterprise of the community it now possesses a golf course, and there are cricket, Rugby and Association football leagues, a band and choral society and a cinema.

Up to the year 1928 the district had suffered what was virtually a seven years' drought, and the difficulty of obtaining and maintaining an adequate water supply was very acute. Bore-holes sunk to a depth of 200ft., however, now give 50,000 gallons of water per day, whilst a reservoir formed by the construction of a dam across a valley at Rifle Creek is filled by a large catchment area and holds 1,300,000 gallons of water, which is conducted to Mount Isa by means of a 12in. pipe line about 20 miles long.

In the sinking of the mine shafts water was encountered, and at one time nearly 2,000,000 gallons per day were being pumped away, but it is anticipated that a regular supply will eventually be taken from this source, and although it is unsuitable for domestic or boiler feed purposes it will be stored and used for mill and smelter process work.

POWER SUPPLY.

Power is derived from coal, and since it has to be

FIG. 1—GENERAL VIEW OF MOUNT ISA MINES AND SURROUNDING COUNTRY

transported some 600 miles, it became important to install highly efficient power plant. Moreover, in order to ensure continuity of supply it was deemed to be desirable to provide storage accommodation for 5000 tons of coal or sufficient for a period of two months. The boilers are of the Babcock and Wilcox type, having a heating surface of 80,000 square feet and burn pulverised coal, which is fed to the bins through an automatic weighing machine, by means of an elevator. From the bins the coal is taken to the pulverising plant and is injected into the boilers by means of fans driven by pipe-ventilated

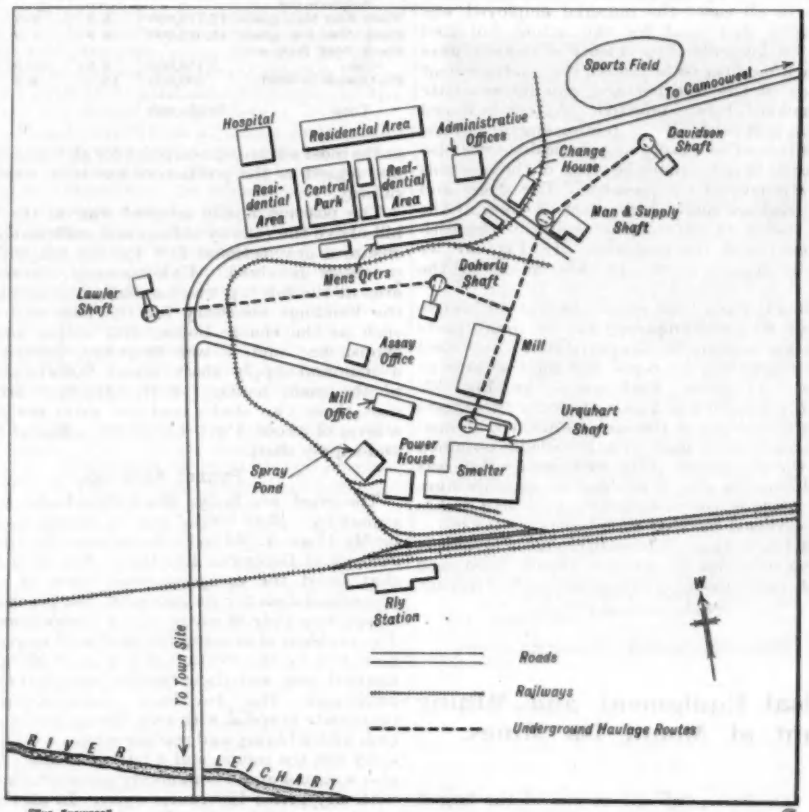

Fig. 2—Map of District Showing Position of Shafts and Mining Plant

motors, as shown in Fig. 3, whilst draught is provided for the boilers by the fans shown in Fig. 4.

Steam at a pressure of 270 lb. per square inch, and at a temperature of 750 deg. Fah., is delivered to two G.E.C. Fraser and Chalmers turbo alternators running at 3000 r.p.m., one of the sets being shown in Fig. 7 on page 424. For heating evaporators for the feed water each set can supply bled steam. Both steam and electrically driven auxiliaries are provided in order to avoid a total shut down owing to failure of either type of drive, but even in the remote contingency of power failure the mine has sufficient oil

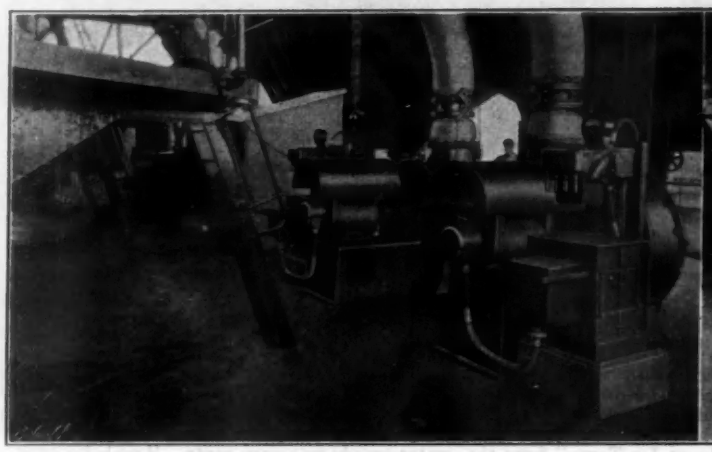

Fig. 3—Fans for Pulverised Fuel Injection

Fig. 4—Forced Draught Fans

engine equipment to maintain the pumping and ventilation of the mine. It is estimated that under the present output conditions of 2000 tons of ore per day the power demand will be well within the capacity of one of the two 5000-kW sets, the other set and its switchgear and cables serving as spare plant. Each alternator has an enclosed air cooling system with water-cooled radiators, and temperature detectors embodied in the stator are connected to alarm bells which give audible warning of any dangerous rise of temperature.

Haulage and Hoisting.

Underground the ore is transported by means of electrically driven trains which run "down grade" when loaded. The locomotives are capable of drawing 100 tons and are fed by a trolley from a 500-volt D.C. supply taken down the man-and-supply shaft from two G.E.C. motor generator sets installed in the compressor sub-station shown in Fig. 8. The trains deliver their load through screens into an ore pocket of 600 tons capacity. The ore hoisting equipment is of the double-drum type, whilst the man hoist has a single drum divided into two compartments. Both hoisting equipments were manufactured and supplied by the General Electric Co., Ltd., the mechanical portions being constructed at the Fraser and Chalmers Engineering Works, Erith, Kent. The following table gives the principal data for both hoists :—

	Ore hoist.	Man hoist.
Net load	7 tons	50 men
Maximum depth	1315ft.	950ft.
Drum diameter	11ft.	11ft.
Rope speed	1900ft. per min.	800ft. per min.
Output	385 tons per hour	480 r.p.m.
Motor rating	1500 H.P.	220 H.P.
Motor speed	480 r.p.m.	650 r.p.m.

Both hoists are controlled on the Ward Leonard system and the ratings of the motor generator units are as follows :—

	Ore hoist.	Man hoist.
Motor	1200 H.P., 3300 volts, 740 r.p.m.	230 H.P., 3300 volts, 765 r.p.m.
Generator	1100 kW, 0/500 volts	150 kW, 0/500 volts

The motor generator of the ore hoist—Fig. 10, page 424—is so arranged that at a future date a flywheel may be added to enable Ilgner control to be adopted.

The mechanical construction of the hoists embraces many new features in winding engine practice, and one of the most important is the system of automatic control. One of the two drums of the ore hoist, shown in Fig. 9 on page 424, is fixed whilst the other is loose on the shaft and is driven through a clutch. Both drums have cast steel cheeks and a cast shell made in two parts and the joints in the cheeks and shell are positioned 90 deg. apart. As they have to carry two layers of rope, special attention was given to the design of the shell. Spiral grooving was adopted and a suitably shaped cam is arranged at the end of the drum to lift the rope from the first layer to the second, and as their positions have a definite relation to the grooving it was possible to cast these cams in one with the inner drum cheeks. The brake parts are cast in one with the outer cheeks and are of the ventilated type with mild steel treads. A special system of ventilation increases the cooling efficiency. The spaces under the brake path are given a spiral formation and the air currents thereby produced at the sides of the path tend to increase the air circulation through the spaces. The loose drum cheeks are fitted with bronze bushes, which are made in two parts, and they can easily be withdrawn and replaced without disturbing any other part of the drum.

In accordance with modern practice the fixed drum is keyed to the shaft without tangential keys. A multiple external tooth clutch sliding on quadrant pieces formed on the drum shaft is employed, and is operated by a compressed air engine controlled from the driver's platform by a hand lever. Four bearings carry the drum shaft and one is placed between the drums. Both the drum shaft and pinion shaft bearings are of the swivelling type, are ring oiled, and the shells are lined with white metal. Double helical gears with machine-cut teeth serve to transmit the drive, and are coupled to the motor through a pin flexible coupling. Each drum is equipped with a set of straight post brakes, which are operated independently by compressed air engines, controlled by two levers from the platform. The actual braking force of the differential gravity brake engines is proportional to the difference between the total air pressure in the cylinder and the dead weight. The air pressure of the variable pressure balanced floating piston valve corresponds to the position of the driver's hand lever.

The engines are also provided with slow braking mechanism, by means of which the rate of application of the brakes is reduced during the full speed part of the wind, this being accomplished by throttling the exhaust from the engine during this period. Timing and throttling are automatically carried out by a cam driven from the drums. A special feature of the improved Whitmore overwinder is the landing zone speed controller, which gives protection against approaching the bank at a dangerous speed. The deceleration of the winder is governed by the rate of fall of a plunger in a hydraulic cylinder, the rate having a gradually decreasing value, which ensures a practically constant deceleration. If the deceleration of the winder does not conform with the predetermined rate, the overwind is operated and the winder is brought to rest.

The control gear of the winder, which may be operated either manually or automatically, represents one of the most modern developments in winding engine practice. For automatic working push buttons are mounted at the various levels, and at the surface, and to change over from automatic to manual control it is merely necessary to operate a lever mounted on the platform. This operation locks the brake levers in the "off" position and places the brake engine of the fixed drum under the control of the solenoid A, shown in Fig. 5. Virtually the winder is then under the control of one set of brakes only but as the winder will be working in balance, and as each set of brakes is capable of holding the maximum torque of the motor, adequate braking is available. The push-button controls at the various points are marked "up," "down," and "stop," and control of the hoist is carried out from one point at a time, which is determined by the setting of the master selector switch mounted alongside the driving

platform. Once this switch is set to the desired point it is locked in position by a responsible person in order to prevent unauthorised operation.

The schematic arrangement of the wiring of the ore hoist is shown in Fig. 6; while Fig. 5 shows the diagrammatic arrangement of the mechanical control gear. From these diagrams the sequence of operations and general principles outlined below will be understood. Assuming that the hoist has been set for automatic operation, and that the skips are in the tipplers with the hoist brakes full on and current switched off from the winder motor, then to start the hoist the "up" button is pressed at the appropriate level, and then released. This operation starts a servo motor which is directly coupled to the controller, and gradually turns it to the full speed position. The rate of acceleration of the hoist corresponds to the angular displacement of the servo motor, and the acceleration of the latter is predetermined to give the correct value.

As the controller is moved round by the servo motor, the first cam switch to operate completes the circuit to the coil of the "suicide" contactor, which, when closed, supplies sufficient armature current to the motor winder to enable it to hold the unbalanced load. The second cam, which is operated by the controller, completes the circuit of the coil of the brakes contactor, thereby lifting the plunger of the solenoid A, Fig. 5. This releases the brakes, and, owing to the air pressure under the engine piston, the air-operated by-pass switch is closed, thus paralleling the controller cam switch with the "suicide" contactor. Further motion of the controller barrel cuts out resistance steps in the circuit of the main generator field, thereby increasing the voltage applied to the winder motor, and increasing the rope speed. As soon as the controller has reached the limit of its travel the barrel opens a cam switch, which stops the servo motor and de-clutches it.

The first part of the deceleration period is controlled in the way usually adopted on Ward Leonard controlled hoists, *i.e.*, by returning the controller to the "off" position by means of cams driven from the drum shaft, and as the speed of the hoist corresponds to the position of the controller the rate of deceleration is governed by the shape of the cams. As this could not be accurately predicted, the cams were cut to shape on site, and the correct form was determined experimentally to give the desired rate of deceleration and to time its commencement at the proper point of the winding cycle. If reliance were placed on the use of cams for stopping, inaccurate decking would result, *i.e.*, the difference in decking points in any two winds would vary considerably, owing to the relatively slow movement of the cams. To overcome this trouble, after the hoisting speed has been reduced to about 8ft. per minute, the cams are made inoperative and the hoist is then under the control of definite stops mounted on the cam wheel. At this point of the wind the controller resistance steps have been reinserted, and the barrel has opened the cam switch in the circuit of the "suicide" contractor, although the latter does not open until the by-pass switch operated by the brake engine has been opened. When the decking point has been reached, one of the stops mentioned operates an air relay, which, in turn, opens a switch in the brake contactor coil circuit. The reason for introducing an air relay is to ensure definite operation of the switch when a certain point in the wind has been reached. As the stop is adjustable, decking can be made perfectly accurate. The opening of the switch in the brake contactor coil circuit applies the brakes, and, in turn, opens the by-pass switch in the "suicide" contactor coil circuit, thus taking all torque from the winder motor after the brakes are applied. In the event of the following contingencies, the cage is protected by the immediate application of the brakes:—(1) Overwind, by the "Whitmore" overwinder; (2) overspeed, by the centrifugal trip; (3) overload, by overcurrent trip; (4) air failure, by an air-operated trip; (5) "emergency stop," by hand-operated push-button trip; and (6) current failure, by the immediate opening of the main oil switch and the consequent tripping of the "brake solenoid."

Besides these safety arrangements, protection is provided against the bottoming of the pistons in the brake engines, a feature of some importance where automatic control is concerned, as there is seldom anyone in the hoisting room to report when the brakes require adjustment and if the pistons bottom the brakes cannot be fully applied. The protective gear takes the form of switches placed in the trip circuit, and mounted on the brake engine in such a way as to open before the pistons reach the bottom of their stroke. Protection is also provided against a skip sticking in its guides. In the event of a skip hanging up at the top of the shaft whilst there is an unloaded skip at the bottom, the hoisting load of the bottom skip would be insufficient to operate the over-current trip and the hoist would pay out slack rope. In order to avoid this trouble, a switch in the safety circuit is arranged so that it will operate if the sag of the rope exceeds a given value. The operation of the "down" button is similar to that of the "up" button. If the cage is at the top of the shaft, the "up" button is out of operation, and if at the bottom, the "down" button is in that condition. The act of pressing the "stop" button operates the emergency trip and brings the hoist to rest relatively slowly under the action of slow braking, and the trip mechanism must then be reset from the driver's platform by a responsible person before the hoist can be restarted. It is then only necessary to operate the "up" and "down" buttons as required. Similarly, in the case of changing levels, the adjustment must be made from the platforms, after which the hoist can be operated as required.

(To be continued.)

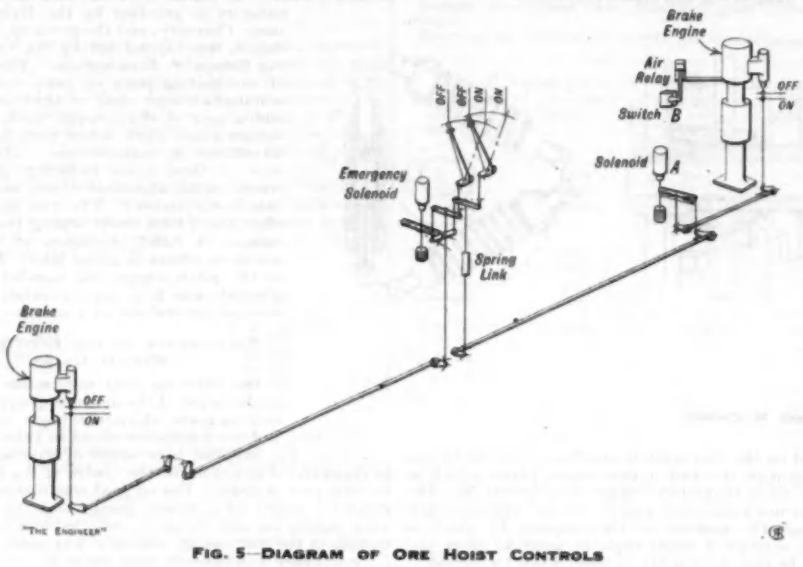

FIG. 5—DIAGRAM OF ORE HOIST CONTROLS

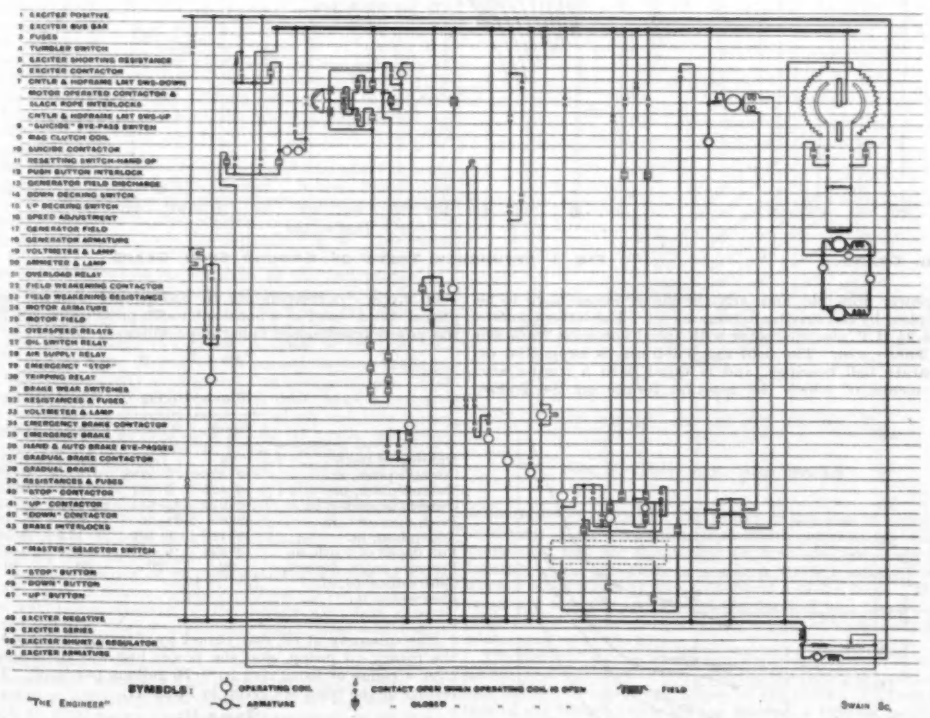

FIG. 6—SCHEMATIC WIRING DIAGRAM OF ELECTRIC WINDER FOR ORE HOIST

SIXTY YEARS AGO.

THE first sentence in the first "Leader" in our issue of April 19th, 1872, strikes one with a shock. "It is perfectly well known to our readers," we wrote, "that we have never manifested any predisposition in favour of steel as a constructive material." At first sight that would appear to indicate an attitude of extreme conservatism; but when it is remembered that Bessemer steel was the material in question and that even to this day there are many who hold that such steel is unsuitable for indiscriminate use, it will be seen that our lack of faith sixty years ago was, to say the least of it, excusable. "Our standpoint," we wrote in explanation, "has always been, and is now, that steel, and especially Bessemer steel, is so uncertain in quality that the utmost caution should be exercised in its use. This is the line we have long adopted. We have never stated, however, that it was impossible to produce a steel which would not only be quite reliable, but might be used as a substitute for iron with great advantage." Subsequent events have justified that anticipation, and, if we may say so, the attitude of this paper towards new inventions and discoveries which it has preserved throughout its long existence. Still quoting from the "Leader" in question, we present another sentence: "The vocation of such a journal as THE ENGINEER is not to resist progress, not to stifle improvement, but to note and describe, and bring before the world, every step in mechanical science which appears to be made firmly, and to rest on a solid basis of fact." One could hardly ask for a more terse and effective statement of the policy of a technical paper which recognises the weight of responsibility which rests upon the Press, and particularly the scientific Press. The subject under discussion was Vavasseur's steel gun, which was built up of a series of hoops. In connection with it we wrote: "Because it was impossible to make a reliable steel gun last year, it by no means follows that it is equally impossible to make a reliable steel gun this year. Such a theory would be opposed to all the teachings of science; and although we are not prepared to state that Mr. Vavasseur has once and for ever solved the problem and taught the world how to make thoroughly admirable steel guns, we feel none the less pleasure in bringing before the notice of our readers particulars of a method of construction which is at least full of promise." We may add that although the method of making the hoops has been modified to some extent in recent years with the improvement of steel, the elements of the system of gun construction invented by Vavasseur have remained in use to the present day.

IT appears from official Canadian reports that the output of coal during the year totalled 12,230,616 short tons, as compared with 14,881,324 tons in 1930; imports aggregated 13,531,831 tons, as compared with 17,620,074 tons in 1930. There was also a drop in exports from 624,512 tons to 359,853 tons. Thus, coal made available for consumption totalled 25,402,594 tons, as compared with 31,876,886 tons during the previous year. The output in Canada during the year included 8,857,195 tons of bituminous coal, 471,302 tons of sub-bituminous coal, and 2,902,119 tons of lignite. The output in Nova Scotia declined from 6,252,552 tons to 4,952,182 tons; Alberta output declined from 5,755,528 tons to 4,562,004 tons, and in British Columbia there was a decline from 2,083,818 tons to 1,876,476 tons Imports of anthracite coal included 2,236,423 tons from the United States, 876,364 tons from the United Kingdom, 4592 tons from Germany, and 60,762 tons from the French East Indies, the total being 3,178,141 tons. Of bituminous coal imports totalled 10,353,690 tons, including 10,231,392 tons from the United States, and 122,298 tons from Great Britain. Coke imports aggregated 733,274 tons, and production aggregated 2,008,386 tons.

An Investigation of the Performance of Gears.*

By J. H. HYDE (Member), G. A. TOMLINSON, and G. W. C. ALLAN.

Introduction.

The investigations described in this paper commenced a number of years ago when the Power Plant Company, of West Drayton, presented to the National Physical Laboratory a gear-testing machine complete with two sets of helical gears.

Preliminary tests showed that the efficiency could be measured on this machine with very high precision, and the results indicated that gears running under normal loads had a considerably higher efficiency than was generally supposed at the time. The machine had one great advantage over existing equipment in that it could be run for long periods without attention and at comparatively small cost. The results of the tests of the original helical gears are given in the next section of the paper, following a description of the machine.

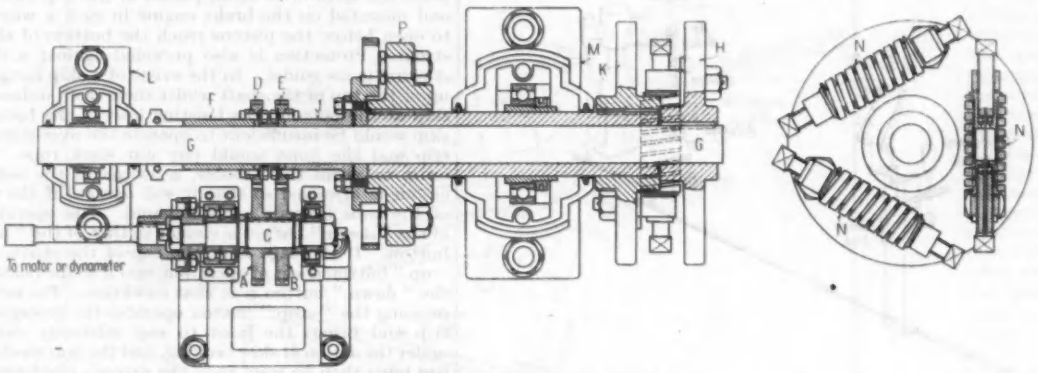

Fig. 1—Gear Testing Machine

The load on the gear teeth is maintained by the torque exerted between the two dynamometer plates which is set up by three calibrated compression springs N. The sleeve J is not connected directly to the dynamometer, but through the medium of the coupling P, which is adjustable through a small angle in order to allow the gear E to be placed correctly in mesh when the dynamometer is in zero adjustment.

It will be seen that the machine utilises the circulation of power principle, and only the power losses have to be supplied by the driving dynamometer. The latter consists of a 2½ H.P. electric motor with speed variation from 800 to 3000 r.p.m. The field magnet frame is supported on separate ball bearings, and is fitted with a torque arm by means of which the reaction torque on the frame, which is equal and opposite to the driving torque, can be measured mechanically. The accuracy of the determination of input power is of the order of 0·01 per cent. when the gears are transmitting 50 H.P.

Of the two similar gears A and B, one is acting as a driver and the other as a driven gear, and the same applies to the other similar pair D and E. The ratio journal bearing is provided for endwise location. The shaft C is coupled flexibly to the driving dynamometer. Of the two mating gears—thirty-eight teeth—D is mounted on the sleeve F, which is attached to the shaft G G and keyed to the shaft and split at one end and provided with a tangent bolt for locking it in position endwise. The opposite end of the shaft is keyed to the outer disc H of the loading dynamometer. The other gear E is mounted on a sleeve J, which is connected to the inner disc K of the dynamometer. The combination is supported in two main ball bearings L and M, as shown. Although the combination rotates as a whole, it is necessary that the sleeve J shall be a good running fit on the shaft to permit the small amount of relative rotation required on account of tooth errors and elastic deflection.

37 : 38 was therefore chosen to be as nearly unity as possible, consistent with the provision of a hunting tooth, in order that the conditions obtaining in each pair should be closely alike.

The gears were enclosed in a sheet iron oil-retaining case, from the top of which oil was supplied by a separate motor-driven pump in two jets, directed on to the teeth as they came into mesh. The rate of supply of the lubricant, which was Sternol special oil, could be varied over a wide range.

The gears used were of oil-hardened nickel-chromium steel, having a Brinell hardness number of 550. The teeth were of standard involute form, with 20 deg. pressure angle, four-module—circular pitch = 4 mm.—and ⅜in. in face width. The blanks were cut and hardened preparatory to grinding by the Daimler Company, Coventry, and the grinding, as already stated, was carried out by the Gear Grinding Company, Birmingham. The majority of the mating pairs of gears comprised a nominally correct gear of thirty-eight teeth and a gear of thirty-seven teeth, in which certain small tooth errors were deliberately introduced in manufacture. These errors were of three kinds including pure pitch errors, radial alignment errors, and involute base circle errors.† The two latter are in effect tooth form errors arising from specific causes. A fuller discussion of the errors and their effects is given later. In the case of the pitch errors the number of teeth affected was five, approximately at equal intervals around the circumference.

Experiments on the Efficiency of Helical Gears.

The following tests were made before the modification of the machine described above, and the gears, which were made of cast iron, had the dimensions shown in Table I.

The oil was supplied in a single cylindrical jet ⅛in. in diameter, directed on to the centre of the face width of each pair of gears. The oil feed was maintained constant by means of a rotary pump, and the lubricant, after passing through the gears, collected in a sump at the bottom of the gear casing, whence it was again circulated.

Preliminary experiments were made to test the effect of the rate of supply of oil on the power lost in the gears. These tests were made at a constant pinion speed of 1000 r.p.m.—corresponding to 3330ft. per minute peripheral speed—and at a constant tooth pressure of 200 lb., the power transmitted being approximately 20 H.P.

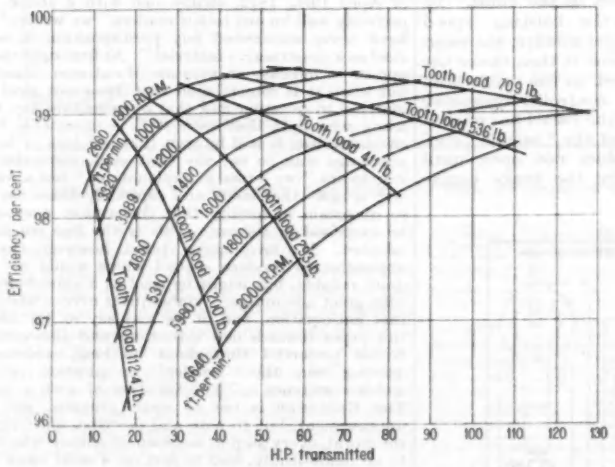

Fig. 2—Efficiency Tests of Helical Gears

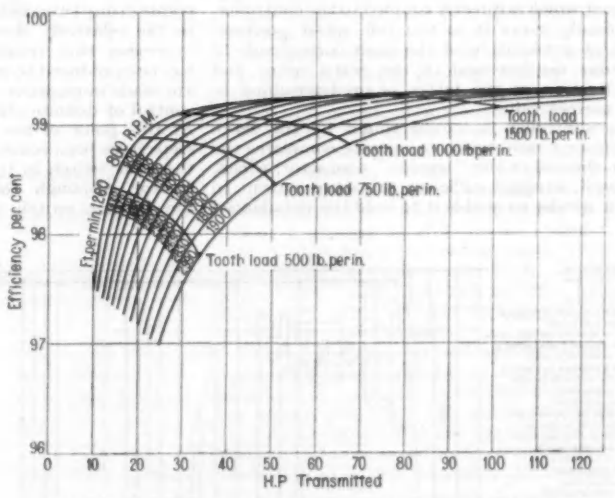

Fig. 3—Efficiency Tests of Ground Spur Gears

Table I.

	Pinion driving.		Wheel driving.	
	Pinion.	Wheel.	Pinion.	Wheel.
Number of teeth	76	153	76	153
Circular pitch, in.	0·5208	0·5208	0·5208	0·5208
Normal pitch, in.	0·451	0·451	0·451	0·451
Outside diameter, in.	12·977	25·614	12·947	25·644
Pitch diameter, in.	12·60	25·40	12·60	25·40
Addendum, in.	0·188	0·107	0·173	0·122
Full depth of tooth, in.	0·331	0·331	0·331	0·331
Pressure angle, degrees	20	20	20	20
Centre distance, in.	19		19	
Face width, in.	4		4	

The quantity of oil was varied by altering the speed of the rotary oil pump, and the power lost was determined over a range of from zero to 9·76 gallons per hour. The results of the tests are given in Table II.

Table II.

Oil supply, gallons per hour.	Horse-power lost.	Efficiency per pair of gears, per cent.
Zero (gears greasy)	0·517	98·74
2·11	0·573	98·62
4·75	0·594	98·56
9·76	0·616	98·50

The results show that the measured loss of power gradually increases as the supply of oil is increased, though the fall of efficiency is small. The experiment serves to illustrate the high degree of accuracy possible in the power measurement.

A further series of experiments was made at zero dynamo-

Several years later there arose a question of carrying out experimental tests to study the properties of hardened spur gears with ground teeth. For this purpose the above machine could be readily adapted in the manner described later. At this time also the accurate gear inspection equipment now in use in the Metrology Department of the Laboratory had recently been developed. All the essential apparatus being available, it was therefore decided to undertake an investigation of the efficiency, wear, endurance, and strength of ground gears. Mr. H. F. L. Orcutt, of the Gear Grinding Company, Ltd., was keenly interested in this projected investigation, and in the preliminary discussion of the subject with him the authors enjoyed the advantage of his long experience of ground gears. In more material ways also they are indebted to Mr. Orcutt for kindly offering to undertake all the tooth grinding necessary for the investigation. It was realised that the particular process used, the formed grinding wheel system, was one in which individual types of error should be under control within fine limits, and therefore it appeared that a profitable line of investigation would be the determination of efficiency, wear, &c., as affected by the presence of certain errors deliberately introduced into otherwise correct gears.

In the original machine the distance between the centres of the pinion and wheel shafts was only adjustable over a range of about 12in. to 18in., which would involve the use of gears much larger than those commonly employed in the automobile industry, in which the most important application of ground gears is to be found. It was therefore decided to modify the machine so that test gears of about 6in. in diameter could be used. The alterations included the provision of new bearings and supports for the pinion shaft, and a new dynamometer of smaller diameter, which could safely be run at high speeds.

A sectional drawing of the testing machine is shown in Fig. 1. The two pinions—thirty-seven teeth—A and B are mounted side by side and keyed securely to a short shaft C running in roller bearings. A deep-groove ball

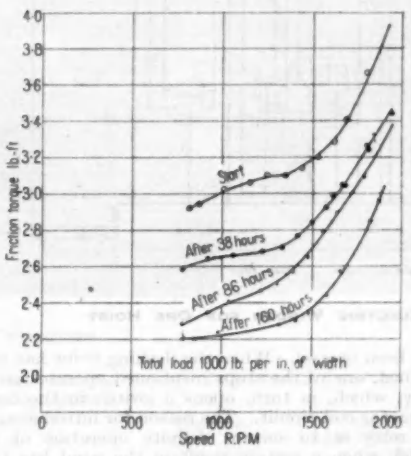

Fig. 4—Effect of "Running-in"

* Paper read before the Institution of Automobile Engineers, April 4th, 1932. We regret to have to record the fact that Mr. Hyde has died since the paper was written.

† The identification numbers of these gears are prefixed with the letters PE, RA, and BC respectively, and all correct gears with the letter C.

meter load and at speeds varying from 800 to 2000 r.p.m. approximately, under two conditions of lubrication. In one case all oil supply was cut off, the gears being merely greasy. In the second case the supply of oil was at the rate of 1·65 gallons per hour, this being the rate of feed finally adopted for the efficiency measurements described later. The results of these tests are given in Table III.

TABLE III.

Speed, r.p.m.	800	1200	1600	1800	2000
H.P. lost, greasy	0·240	0·580	1·230	1·725	2·400
H.P. lost, lubricated	0·250	0·630	1·310	1·815	2·480

A series of experiments was made at tooth pressures varying from 112 lb. to 709 lb., with speeds varying from 800 to 2000 r.p.m. of the pinion shaft, corresponding to peripheral speeds of 2660ft. to 6640ft. per minute. The full results are shown by the family of curves in Fig. 2, which clearly shows the relative influences of speed and load. These results should be compared with those for ground spur gears given in Fig. 3.

Some additional tests were made to ascertain the effect on the efficiency of variations in the centre distance of the gears. These tests were carried out at a tooth pressure of 200 lb., and at a pinion speed of 1000 r.p.m., and led to the results given in Table IV.

TABLE IV.

Centre distance.	Efficiency, per cent.
0·01in. short	98·53
Nominal	98·63
0·02in. long	98·72
0·04in. long	98·76

The effect observed is probably due to a progressive reduction in the work done on the lubricant.

In Table V. are given the maximum designed loads and

TABLE V.

H.P.	Pinion speed, r.p.m.	Efficiency, per cent.
52	2000	97·50
45	1500	98·45
37	1000	99·00

speeds of the gears as specified by the makers, with the measured efficiency in each case.

The maximum efficiency obtained was at a tooth load of 709 lb. at a pinion speed of 800 r.p.m., transmitting 56·5 H.P. when the efficiency was 99·44 per cent.

RESULTS OF EFFICIENCY TESTS ON GROUND SPUR GEARS.

The set of ground gears selected for the efficiency and wear tests comprised two pairs, each having one nominally correct gear meshed with a gear having small pitch errors. This scheme of test gears was chosen because preliminary measurements of efficiency had indicated that the small errors introduced produced no significant effect on the efficiency, but might not be without some effect on the amount of wear. For such a purpose the gears having pitch errors are well adapted, since a direct comparison presents itself in the one gear, between the majority of correct teeth and the few isolated incorrect teeth. It is shown subsequently that nothing definite was established in this connection, because the gears always failed by fracture of the teeth before any appreciable wear had occurred.

The first series of tests brought to light an effect of some interest, if not entirely unexpected. It was found that the power absorbed by the gears when running at constant load and speed diminished continuously for a considerable time, as can be seen from the curves in Fig. 4. This effect can only be ascribed to the gradual polishing of the tooth surfaces, which could be observed as the test proceeded. The length of time concerned, as indicated in the figure, precludes the possibility that the effect was one caused by slow temperature changes, as a constant temperature was reached after about two hours' running under the condition of this test. Moreover, no variations were made in the rate of oil supply throughout this complete test. The extent by which the absorbed power diminishes is perhaps surprising in the present case, in which the new gears possess already a good ground finish. It can be seen that the power absorbed falls in 160 hours by about 25 per cent. independent of the speed. In their initial condition the direction of the grinding grain runs perpendicular to the direction of motion, and there is little doubt that the slow polishing away of this grain is responsible for the increase that occurs in the efficiency. This bears out all previous experience with worm gears.

A complete family of efficiency curves, typical of these ground gears, is shown in Fig. 3. These curves are derived from the measurements of the power absorbed shown plotted in Fig. 5, the measurements being taken subsequent to running-in of some hours' duration under heavy tooth load, to produce the state of polish shown to be necessary for consistent results. The curves in Fig. 3 show the variation of efficiency with power input for a speed range of 800 to 1900 r.p.m. and for a torque range of 95 lb.-ft. to 560 lb.-ft., corresponding to a tooth load range of 500 lb. to 3000 lb. per inch of tooth width. It can be seen that the curves for all speeds tend to approach about the same limiting value of approximately 99·4 per cent. The effect of the speed at the lower tooth loads, which are more comparable with those which would obtain under practical conditions, is quite marked, and clearly tends to become more so with further reduction of load.

ENDURANCE TESTS.

In order to investigate the wear and endurance of the gears a series of continuous runs of long duration was made with the results summarised in Table VI. It was initially intended to make measurements of the wear at regular intervals, and so correlate wear with the conditions of load and speed. For this reason the first two series of tests in the table were made in stages. It was found, however, that only a very slight amount of wear could be detected after each stage, notwithstanding the high value of the load and the large number of revolutions made. For example, the measurements made in the first test after 45 million revolutions—500 hours at 1500 r.p.m.—showed that the wear of the driving faces did not exceed 0·001in. It was not possible to accelerate the rate of wear by further increasing the load, as fracture of the tooth quickly ensued at a load of 2000 lb. per inch. It was clear from this result that there was little to be gained by attempting any systematic investigation where the rate of wear was so extremely small, and the subsequent tests were confined to tests of endurance.

TABLE VI.

Results of endurance tests. Fractured gears indicated by an asterisk.

Pinion speed, 1500 r.p.m.—2360ft. per minute peripheral.

Numbers of gears in the set.	Load per inch of tooth width, lb.	Number of revolutions to tooth fracture, millions.	Initial equivalent error in tooth pitch, inches.
P.E. 39—*	1000	30	0·0005
C. 23—	1500	15	
P.E. 40—*	2000	1·1	
C. 24—			
P.E. 43—*	1000	30	0·0005
C. 27—	1500	22·5	
P.E. 44—			
C. 28—			
R.A. 53—*	1500	6·6	0·0005
C. 13—			
R.A. 54—*			
C. 14—			
R.A. 51—	1500	23	0·0009
C. 11—			
R.A. 52—*			
C. 12—			
B.C. 45—	1500	10	Less than 0·0002
C. 21—			
B.C. 46—			
C. 22—*			
B.C. 47—	1500	25	0·0005
C. 17—			
B.C. 48—*			
C. 18—			
B.C. 49—	1500	3·2	0·0009
C. 19—*			
B.C. 50—			
C. 20—			

The mating gears throughout these tests consisted of two pairs, each comprising a thirty-eight-tooth wheel having all dimensions nominally correct, and a thirty-seven-tooth wheel in which certain small tooth errors were

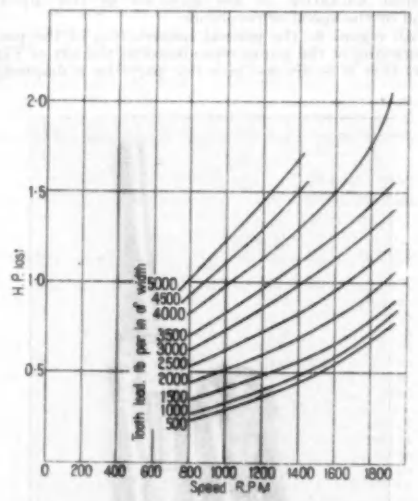

FIG. 5—LOST H.P. AND SPEED

deliberately introduced. The object in this was to acquire experimental data regarding permissible errors as affecting endurance, and for this reason an attempt was made in manufacturing the gears to produce errors graded somewhat in magnitude, as seen in column 4 of the table. The errors are actually specified in the form of real or virtual pitch errors, a procedure which is explained more fully in a later section of the paper.

The result of this series of tests are clearly not very consistent, and this must be attributed to the fact that in every case failure occurred by fatigue of the tooth. Examination of the broken teeth always showed a typical fatigue fracture originating in the vicinity of the root radius. It is shown later, moreover, that there is much uncertainty as to the maximum stresses set up in the teeth, under running conditions, so that as fatigue tests the circumstances were inevitably by no means ideal. For these reasons the results of Table VI., based as they are on a single observation in each test, are not claimed to be well-established values of the endurance of gears, but they are given here rather for the sake of certain indirect conclusions which they indicate.

It will be seen that of the two sets of gears having a radial alignment error (R.A. 51 to R.A. 54), the set with the larger error had a considerably longer life, and a similar effect occurred amongst the gears with an error in base circle radius. These pronounced anomalies suggest that some other consideration has overwhelmed the influence of the tooth errors on the endurance of the gears. Experience of ordinary fatigue testing suggests that the exact form and surface condition of the root fillet, at which the fracture commenced, will have a most important effect on the fatigue strength. In particular, the presence of the grinding marks, running at right angles to the direction of maximum stress, introduces a variable factor into the resistance to fatigue.

Certain other tests have been made which bring out clearly the very important part played by the root radius. Two pairs of gears were used in which the form of the root was a semi-circle running tangentially into the two involute curves, thus giving fillets of the maximum possible radius. Compared with the gears having the more usual form of root, the modified teeth were found to have about five times the endurance, tested under similar conditions, although the static bending strength of the tooth was reduced by nearly 50 per cent. as a consequence, presumably, of the increased length of tooth. This result, although of considerable interest, must again be subject to the reservation that it is based on a single set of specimens fractured by fatigue.

Although in the endurance tests an apparently unimportant clearance dimension of the tooth has largely controlled the results, this is not to imply that the tooth errors are of small consequence. On the contrary, there is good evidence that the endurance is reduced to a large extent by the acceleration stresses which become added to the mean stress due to the load, as a result of the disturbing effect of the errors on the kinematic action of the teeth.

This is shown by the magnitude of the tooth load, 1500 lb. per inch of width, which in every case is sufficient to cause a fatigue failure. Static tests of the breaking load of these teeth, described in a later section, prove that the tooth fractures under a steady load of as much as about thirty times the above load. On the other hand, the limiting fatigue stress of this material is well known to be not less than about one-quarter of the ultimate tensile strength. It is, therefore, certain that the effective stresses set up in the running tests must greatly exceed those due to the steady torque alone.

The endurance tests which include the gears with small real pitch errors further confirm these conclusions, since two out of three of the failures occurred at teeth definitely out of pitch, whilst none of the correct gears used in mesh with these gears showed signs of failure.

The serious consequences of small tooth errors have been investigated further from the kinematic standpoint by means of a special device incorporated in the gear-measuring machine. A pair of gears can be rotated in mesh under a small tooth load, and a record is made showing all the variations from a uniform velocity ratio. An actual record for the pair of gears C. 12 and R.A. 52 is shown in Fig. 6. The trace represents one revolution

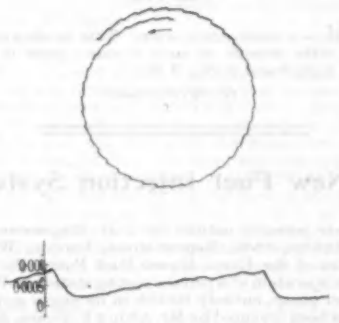

FIG. 6—RECORDS OF PITCH-LINE MOTION

of the thirty-eight-tooth wheel and the radial divergencies from a perfectly smooth spiral give the magnitude of the variations in velocity ratio on an enlarged scale. The effect of the error in radial alignment of the tooth can be seen as a periodic irregularity in the relative velocity, recurring with the passage of every tooth. This takes the form of a comparatively gradual displacement of the gears, which takes place as the point of contact of the mating teeth progresses along the involute, followed by an abrupt return corresponding to the engagement of the next pair of teeth, which have become virtually slightly out of pitch.

The accuracy with which this record is produced is such that the recorded periodic error may be considerably enlarged for purposes of measurement, as seen at the foot of Fig. 6, where a portion of the record is shown enlarged optically. A scale has been added showing the magnitude of the error in linear units at the pitch circle. The record, for any assumed speed of rotation, constitutes an actual displacement-time curve of the gear pitch circle, and some interesting conclusions can be reached by computing the maximum acceleration from this curve. The acceleration which would occur in the neighbourhood of the peak in the record, corresponding to the speed of 1500 r.p.m., is of the order of 25,000ft. per second per second if the gear teeth were perfectly rigid.

On calculating the tooth pressure which would be necessary to impart this acceleration to the gear, it is found to amount to approximately 3000 lb., or 4000 lb. per inch of tooth width. The momentary tooth pressure, if the teeth were perfectly rigid, would, therefore, approach a value four times as great as the mean steady pressure of 1500 lb. per inch due to the load. There is little doubt that the elasticity of the teeth greatly modifies the pitch-line motion, reducing the acceleration and tooth pressure. Thus, in the case illustrated in Fig. 6, the pitch-line displacement measured on the enlarged record is 0·0008in., and the tooth pressure exerted on the tip of the tooth to cause an elastic deflection of this amount is about 1950 lb. This estimate is obtained from the results of a later section in which measurements of the elastic deflection of the teeth are described. On this basis the sudden increment of tooth pressure is only half the value that would occur with rigid teeth, and the acceleration will be correspondingly reduced. Nevertheless, the effective tooth load is more than doubled by the presence of the small error in radial alignment.

The above considerations apply equally to the effect

of pitch errors or errors in base circle diameter. In the former the same type of shock occurs at the engagement of two teeth of slightly different pitch. This may be seen from Fig. 7 (*a*), which shows the velocity ratio record of the pair of gears C. 27 and P.E. 43, with a portion of

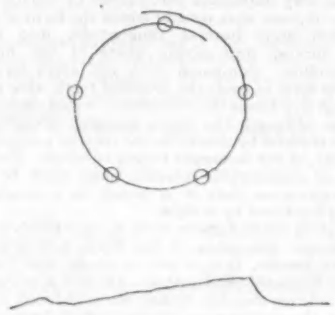

FIG. 7 (*a*)

the record, including the engagement of a tooth with a pitch error, shown magnified 14½ times. In the case of the base circle error the kinematic action of the teeth is closely similar to that already described as produced by a radial alignment error, every tooth coming into engage-

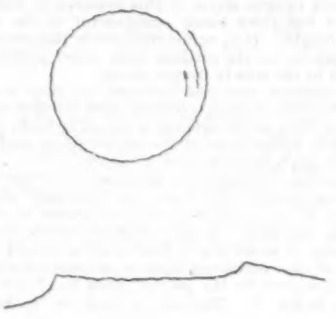

FIG. 7 (*b*)

ment with a virtual pitch error. This is shown by the velocity ratio records of such a case, gears C. 19 and B.C. 49., reproduced in Fig. 7 (*b*).

(*To be continued.*)

A New Fuel Injection System.

We were recently invited by E-H. Engineering, Ltd., 20–22, Maddox-street, Regent-street, London, W. 1—the proprietors of the Evans Diesel Fuel Pump Patents, to inspect in operation at a private testing station at Wembley a new fuel pump, entirely British in its origin and design, which has been invented by Mr. Arthur F. Evans, M.I.A.E., and has been developed jointly with Mr. Stanley Hopkins, and is, therefore, styled the E-H. fuel pump.

In what follows we give an illustrated description of the pump and its new principle of operation and append a technical report by Dr. S. G. Davies, Ph.D., M.Sc., M.I. Mech. E., on some engine tests made with the pump at Wembley on Thursday, March 24th.

The E-H. Fuel Pump.

In the development of the heavy-oil engine, particularly the high-speed type, much attention has recently been paid to questions of combustion chamber design, cylinder turbulence, auxiliary air cells, and forms of jet, but the equally important factor of fuel pump performance has not perhaps received the attention it undoubtedly deserves. As, in our opinion, more perfect combustion in the engine cylinder over the widest range of loads will only be achieved with full understanding and control of the injection process, whatever the cylinder diameter or the speed of the engine, it will be of interest to our readers to follow the design of a pump which has taken into account the effect of wave formation in the fuel pipe, and has utilised this effect to achieve a positive point of injection and cut-off, with a wide range of flexibility. When designing the E-H. pump, the objects in view included the elimination of all unharmonic or unbalanced motions which might place a restriction on operating speeds. To this end, the pump plungers and the pump sleeves are worked by excentrics, having comparatively long strokes. Again, it was desired to provide sufficient overlap to allow the pump to function properly, even in the remote event of appreciable wear taking place. This end was accomplished by making full use of the compression of the fuel in the pipe line to the jet, and the waves thereby formed, which, it has been established, travel to the jet at a speed of approximately 4000ft. per second. In order to produce a substantial wave it was found that a very rapid valve rate was required. By moving the pump plunger in a direction opposite to that of the sleeve and by utilising the whole of the periphery of the plunger as a valve lip, and bringing the lip into operation at or about the point of maximum velocity, a wave is created which travels to the jet at about 4000ft. per second, and enables the pressure rise, which is a function of that wave, to be accomplished in but a fraction of a degree of the crank shaft movement. By these means it became possible to ensure a rise of fluid pressure well above that needed for efficient spraying in the minimum period of time, and also to provide a complete control of the pressure and the form of the pressure line. The rise of pressure following the compression of the fuel continues to increase until a balance of flow and plunger displacement is reached, which pressure is then continued until the desired termination of injection takes place. On the return stroke, the sleeve passes through an adjustable muff until the position is reached when the lower part of the muff uncovers a port leading from the compression space through the wall of the sleeve.

At this point the fuel is under compression in the line and the sudden release of the pressure causes a negative wave to travel to the jet, also at about 4000ft. per second. There is thus again a rapid alteration and reduction of the pressure to zero, and the impulse so created acts on the non-return valve, which is placed close to the jet, causing it to close, and in doing so, to withdraw, to a slight degree, the oil from the jet. It is found that as the building up of the pressure is so rapid it may be represented

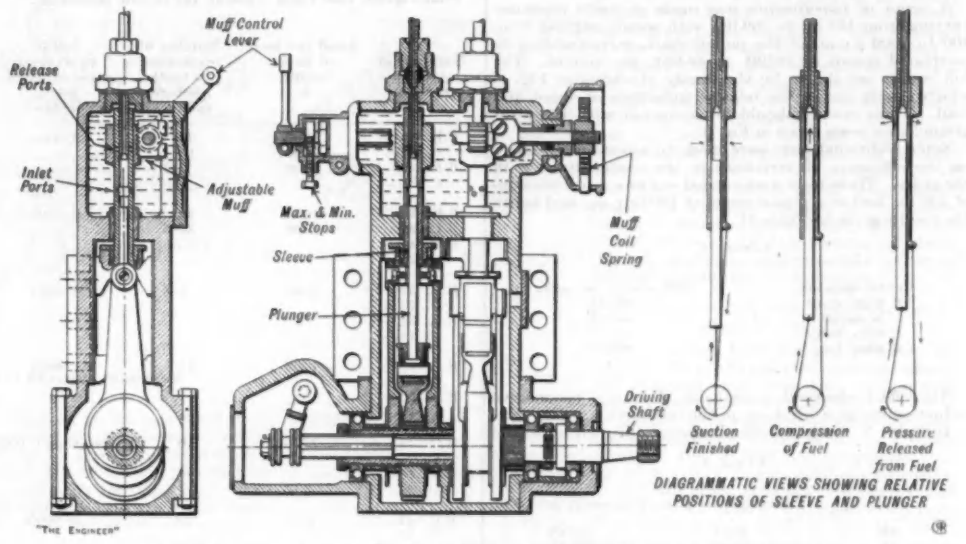

FIG. 1—Sections of E-H. Fuel Pump Showing Method of Working

by a practically vertical line, and as the fall in pressure is also of the same order, it follows that that part of the cycle between these two points may be reduced till these points almost coincide without any alteration of the character of the jet or spray. It has also been shown that no matter what speed of rotation is employed, the only effect is that the amplitude of the wave is increased and the line of pressure rise departs further from the vertical. As, however, in this case, the efficient pulverising pressure is reached even sooner, the actual angular period is not extended, and, in consequence, there appears to be no practical limitation of the duration of the injection period or the speed of revolution.

With regard to the general construction of the pump, the drawing of the pump reproduced to the left of Fig. 1 shows that it is divided into two parts by a diaphragm.

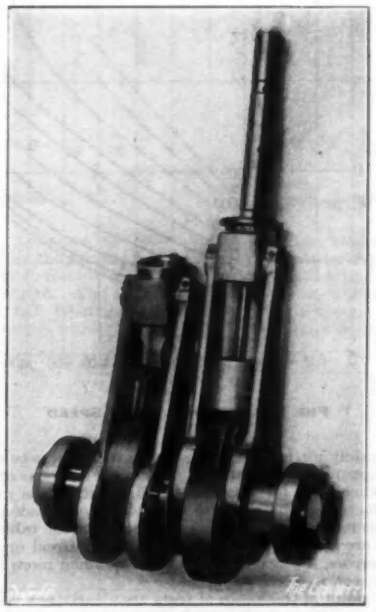

FIG. 2—Plunger and Sleeve Unit

The upper part of the pump is a fuel reservoir, and it contains the plungers and sleeves and the regulating mechanism. The moving sleeve carrying the plunger passes through a gland to the lower chamber containing the excentric shaft and the excentrics, of which there are three to each line, the one at the centre operating the plunger and the others the sleeve.

The excentric rods are coupled to pins in the crossheads, which work in guides, while both the sleeve and plunger float in the crossheads in the usual manner.

Reference to the centre section shows that the right-hand end of the excentric chamber is an end plate and bearing housing. At the other end there is the timing-gear box, in which is housed a mechanical arrangement for altering the phase of the pump relative to that of the engine. The adjustment, which is made by a lever, can be arranged for any number of degrees according to requirements.

The pump is so constructed that it can be operated in either direction and can be driven from either end. The pump body, which, it may be noted, is suitable for a pump to operate two cylinders having a bore of 6in., is 13in. in height.

The diagrams which are reproduced to the right of Fig. 1 show relative positions of sleeve and plunger. In the first diagram the plunger is just commencing its upward stroke, while the sleeve is starting to move downwards. During this movement the surplus oil passes through the port between the fixed and moving plungers till just before mid stroke, when the velocity of both sleeve and plunger is approaching the maximum. The plunger over-runs this port at a very high valve rate. In the diagram the ports are shown for clearness as holes, but in practice they consist of internal and external grooves respectively with communicating holes.

The wave which is produced when the port is over-run, can travel without impedance through the fixed plunger along the pipe to the non-return valve at the jet, and thus the pressure of the wave is applied to the jet. The commencement of delivery is shown in the second diagram, and it continues for such a period as the position of the muff surrounding the sleeve allows, for as the sleeve passes downwards through this muff the upper port eventually passes below the release edge of the muff. This position is reproduced in the third diagram. The valve rate of this port is also high, and this sudden release of pressure at the base of the column of compressed fuel causes a negative wave to be formed which travels upwards to the jet.

It will be seen that the only unbalanced force is the sudden application of pressure to the end of the plunger which is, however, partly balanced. As the plunger, crosshead, and excentric and rod can, however, be of considerable mass, most of the shock is dealt with by the inertia of the moving mass and very little communicated to the pump itself.

From the foregoing it will be realised that if the release port opens immediately after the by-pass port is closed, the wave will still travel to the jet, even if the negative wave immediately follows, and the actual duration of the injection period, therefore, can be reduced to a degree or so of crank shaft movement without in any way curtailing the initial pressure at the jet, the time required to build up this pressure, or the angular period of the fall to zero.

In setting out the injection characteristics by selecting the plunger diameter, the angular period for the delivery of a given weight of oil can also be readily adjusted, and by selecting the capacity of the fuel line, the balance pressure can be determined. Again, as illustrated, when the by-pass is closed, the plunger is accelerating. If necessary, it can be closed earlier and the amount of acceleration be increased, or the injection period can be arranged while the plunger is decelerating. All these variations are possible, and in this way any desired injection characteristics can be secured.

On the occasion of our visit to Wembley, the pump was tested on the bench and engine at various speeds up to 2000 r.p.m., this being the limit of available drive. At all speeds the pump was, we noted, free from vibration and quiet in operation. We found that the timing gear could be easily operated by moving the small lever, and that there was no reaction at all on the lever employed for adjusting the axial position of the muffs.

It was further demonstrated that even with no head of oil the pump operated a 0·012in. plain jet with a non-return valve, and rapidly cleared all air from the line. At maximum throttle a 3ft. spray appeared at the jet, and by calibration this was found to be equal in volume to the requirements of a 30 H.P. cylinder. The whole of the spray appeared to us to be uniform in size, and it fell to the ground at a speed of approximately 1ft. in two seconds. By testing the jet with a sheet of white paper we confirmed that the impulses were quite sharp and equally spaced. When the output was reduced the character of the spray appeared to remain constant, right down to the minimum delivery which could be observed, and under these conditions the impulses remained quite distinct and there was no dribble. Even at these low settings the delivery appeared to be quite constant. The independent adjustment of each pump was shown to be readily carried out.

Dr. Davies' Report.

The object of the tests described in this report was to afford evidence of the satisfactory performance of the E-H. fuel-injection pump when applied to an engine. The tests were carried out at Wembley, Middlesex.

A Junkers single-cylinder, opposed-piston engine, type 1 H.K. 65, was used, and the investigation consisted essentially of the repetition of two separate series of tests, one series at constant speed and varying brake mean effective pressure, and one at varying speed with observation at each speed of the maximum brake mean effective pressure. The engine was at first equipped with

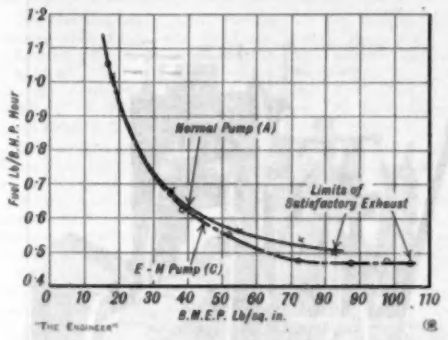

FIG. 3

its normal injection gear and the two series of tests were made; the E-H. pump was then substituted for the normal injection pump and the two series were repeated, thus giving opportunity of direct comparison of the performance of the latter with that of the standard fuel-injection equipment.

The engine used is of the usual Junkers two-stroke,

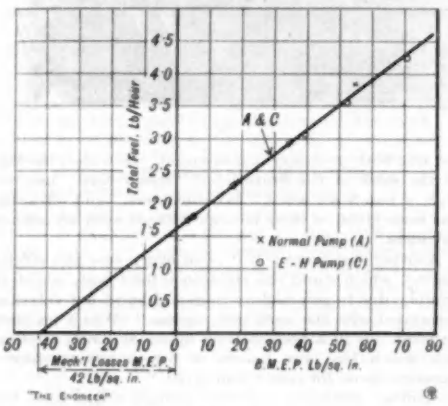

FIG. 4

opposed-piston design, and has a cylinder diameter of 65 mm. (2·56in.), and a combined piston stroke of 210 mm. (8·27in.). Its method of working is commonly understood—see, for instance, THE ENGINEER, September 5th and 12th, 1930—and it is only necessary to refer here to those features that are of importance to the present investigation.

As the tests confirm, the brake mean pressures normally

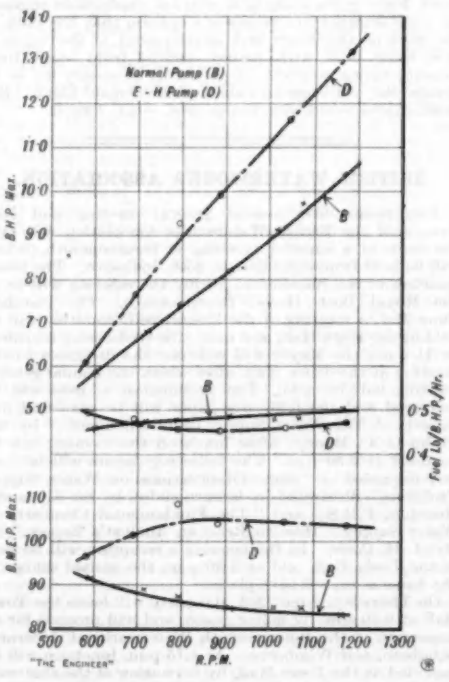

FIG. 5

realised in this engine are relatively high when the small cylinder dimensions are borne in mind. When, however, the relatively high values of the mechanical losses—the tests show that these expressed as mean piston pressure are about 42 lb. per square inch (see Fig. 4)—are taken into account, it is clear that the indicated mean pressures are definitely high, being under normal conditions of the order of 125 lb. per square inch. These high pressures, combined with the low consumption per indicated horse-power hour of 0·320 lb. realised, confirm that the combustion of the fuel must be very efficiently carried out with this engine when in its standard form. It is thus, from the point of view of combustion, a satisfactory engine on which to investigate the behaviour of special injection equipment such as that under test.

The speed of revolution of the engine was limited by considerations of mechanical design to 1200 r.p.m. This is, of course, low in relation to current practice. But, when it is remembered that the engine works on a two-stroke cycle, the corresponding pump speed, being the same as that of the engine, corresponded to speeds of double these quantities. In the case of a four-stroke engine, and, in the actual tests, this corresponded to speeds of 2350 r.p.m. The period of injection actually used would, of course, be relatively double that corresponding to similar combustion conditions in a four-stroke engine running at double the speed of the pump.

The standard fuel pump used in this engine is a Junkers single-plunger pump of conventional single-plunger design. It delivers through a double ball-type non-return valve into the piping, and injection takes place through an "open" nozzle. The nozzle gives two impinging streams which produce the fan-shaped spray typical of the Junkers design.

In the substitution of the E-H. pump for the standard pump, a single non-return valve was substituted for the standard Junker type of non-return valve, and was placed next to the nozzle. In no other respects were changes made.

The observations made during the tests were: The fuel consumption, the brake load, the speed of revolution, the outlet temperature of the circulating water, the pressure of the scavenging air, the state of the exhaust, and the temperature and barometric pressure of the air supply to the engine.

The fuel was measured by observing by stop-watch the interval of time taken to consume a calibrated volume of fuel. A Heenan and Froude brake absorbed and measured the power of the engine; this was afterwards disconnected and checked. A counter gave the speed of revolution of the engine. The temperature of the circulating water was controlled so that the conditions obtaining during the comparative series of tests were consistent.

The scavenging pressure was recorded by a Bourdon gauge. The exhaust was led to a silencer and then through a pipe about 12ft. in length to the open air, where it could be readily observed.

The fuel used was a Shell Diesel oil. Samples were taken and tested in the laboratories at King's College, London, and gave the following results:—Specific gravity, 0·875 at 63 deg. Fah.; viscosity, 51 secs. at 63 deg. Fah. (Redwood No. 1); flash-point, Pensky-Martin, 165 deg. Fah. The suppliers gave the gross calorific value as 19,300 B.Th.U. per pound.

The four series of tests are indicated by the letters A, B, C and D, that being the order in which they were carried out. A and B relate respectively to the series at constant speed and at maximum output with the normal Junkers equipment—given as "normal pump" in the figures—while C and D relate respectively to the series at constant speed and at maximum output, with the E-H. pump. The data for the series A and C at constant speed are tabulated in Table I., while those for the series B and D at maximum output are tabulated in Table II.

The engine had been run for some time previously, and at the commencement of the tests was thoroughy warm. Series A was run by increasing the load in steps from "no load" up to the load at which the exhaust was definitely visible, given by test No. 6A. This latter condition was regarded throughout all the tests as the limit of "satisfactory exhaust." This limit is an arbitrary one, and might be regarded as somewhat exacting, but in view of the fact that many designs of engines do actually attain this standard, it does provide a fairly definite criterion.

Series B was next run by reducing the speed in steps, the load being so adjusted at each speed that this condition of the exhaust was retained. The tests in series B were thus all taken at the respective values of B.M.E.P. consistent with the "limit of satisfactory exhaust," and are thus considered as maxima. It would be generally possible to exceed these values, but only with an accompanying exhaust too black to be deemed "satisfactory." When the speed had reached a value roughly half of its maximum value, the series was terminated. The injection equipment was next changed from the normal to the E-H. pump. The tests of series C and D were then consecutively carried out, following through the same procedure as in series A and B.

Fig. 3 gives the results of series A and C plotted as fuel consumption in lb./B.H.P./hour on a base of B.M.E.P., and shows clearly the greatly improved performance of the engine with the E-H. pump over that given with its normal equipment. The maximum B.M.E.P. is increased

TABLE I.—*Test Series at Constant Speed.*

Barometer, 29·95in.; air temperature, 54 deg. Fah.

Test No.	Speed, r.p.m.	B.M.E.P., lb./sq. in.	B.H.P.	Fuel, lb./hr.	Fuel, lb. B.H.P./hr.	Scavenging pressure, lb./sq. in abs.	Exhaust.
1 A.	1173	4·0	0·50	1·77	3·540	20·6	Clear*
2 A	1158	18·3	2·27	2·30	1·012	20·6	Clear
3 A	1182	35·0	4·44	2·96	0·666	20·8	Clear
4 A	1173	54·6	6·88	3·83	0·556	21·0	Clear
5 A	1169	72·3	9·06	4·79	0·528	21·0	Clear
6 A	1171	83·0	10·41	5·19	0·498	21·1	Slightly black
1 C	1175	4·7	0·59	1·79	3·03	20·3	Clear*
2 C	1171	17·3	2·18	2·26	1·037	20·5	Clear
3 C	1171	39·2	4·94	3·06	0·619	20·7	Clear
4 C	1160	51·4	6·37	3·53	0·553	20·7	Clear
5 C	1171	70·6	8·89	4·23	0·476	20·9	Clear
6 C	1167	87·5	10·96	5·18	0·472	21·0	Clear
7 C	1169	98·9	12·40	5·88	0·474	21·2	Just visible
8 C	1181	103·7	13·18	6·13	0·466	21·5	Slightly black

* The exhaust was slightly blue throughout series A and during the first three tests of series C, indicating over-lubrication. During the later tests of series C there was no sign of over-lubrication.

from 83·0 lb. to the quite high value of 103·7 lb. per square inch, an improvement of 25 per cent., while the best brake thermal efficiency is also improved by some 5 per cent. since the consumption is reduced from about 0·5 lb. to 0·47 lb./B.H.P. hour. Since the tests, however, relate essentially to the combustion processes, it is desirable to estimate the corresponding change in the indicated performance of the engine.

Fig. 4, giving total fuel consumption in pounds per hour on a base of B.M.E.P., was therefore plotted. For the smaller values of B.M.E.P., when the excess of air in the cylinder is always considerable, it may be assumed that the power developed on the piston is directly proportional to the fuel consumed. That such is the case is supported by the facts that the points for the respective series lie closely on a straight line. If, then, this line is produced back to cut the horizontal axis, it will give the point of no output; in other words, the distance of the points of intersection from the point of zero B.M.E.P. gives, very approximately, the mechanical losses of the engine. This as seen on Fig. 4 is equivalent to about 42 lb. per square inch.

Using this value, it is seen that the maximum indicated

TABLE II.—*Test Series at Maximum B.M.E.P.*

Barometer, 29·95in.; air temperature, 54 deg. Fah.

Test No.	Speed, r.p.m.	B.M.E.P., lb./sq. in.	B.H.P.	Fuel, lb./hr.	Fuel, lb. B.H.P./hr.	Scavenging pressure, lb./sq. in. abs.	Exhaust.
1 B	1171	82·9	10·4	5·18	0·498	21·1	Slightly black†
2 B	1074	84·5	9·75	4·69	0·481	20·7	" "
3 B	1015	84·3	9·18	4·42	0·482	20·5	" "
4 B	908	84·3	8·21	3·96	0·482	19·9	" "
5 B	794	86·5	7·38	3·53	0·479	19·4	" "
6 B	720	88·1	6·81	3·21	0·471	18·9	" "
7 B	602	90·9	5·87	2·71	0·462	18·6	Black
1 D	1181	103·7	13·17	6·13	0·466	21·5	Slightly black†
2 D	1038	104·3	11·64	5·36	0·461	20·7	" "
3 D	887	104·0	9·92	4·44	0·448	19·8	" "
4 D	794	108·3	9·24	4·24	0·459	19·5	" "
5 D	695	101·4	7·58	3·62	0·478	19·0	" "
6 D	583	96·4	6·04	2·95	0·489	18·5	" "

† There was a blueness in addition in series B, indicating over-lubrication.
The exhaust in series D was otherwise clear, indicating that lubrication was not excessive.

M.E.P. with the normal pump is 125·0 lb. per square inch and with the E-H. pump this is no less than 145·7 lb. per square inch. That such an extremely high value was obtained on this small engine and with the exhaust only just visible is, in my view, a noteworthy achievement.

With the great increase of maximum M.E.P. realised with the E-H. pump at 1175 r.p.m., the better performance at all speeds over the range from 600 to 1200 r.p.m. is to be expected. The data of Table II. for series B and D are plotted in Fig. 5 on a base of revolutions per minute, the three pairs of curves being respectively B.H.P., specific fuel consumption, and B.M.E.P. The normal speed of revolution of the engine with the standard equipment is 1100 r.p.m., but it is seen that with the E-H. pump the superiority of performance, both as regards output and economy, increases steadily with speed.

There is one small matter relating to the footnotes at the bottom of the tables which is deserving of comment. During series A and B and during part of series C the engine was slightly over-lubricated, as shown by the presence of oil vapour in the exhaust. This condition then vanished, and during the remainder of series C and during series D there were no such signs. If lubricating oil were being burned to any considerable extent while over-lubrication existed, this was the case when the engine was running with its normal injection gear. During most of the tests with the E-H. pump there was no excess of lubrication. Thus any advantage on this account would

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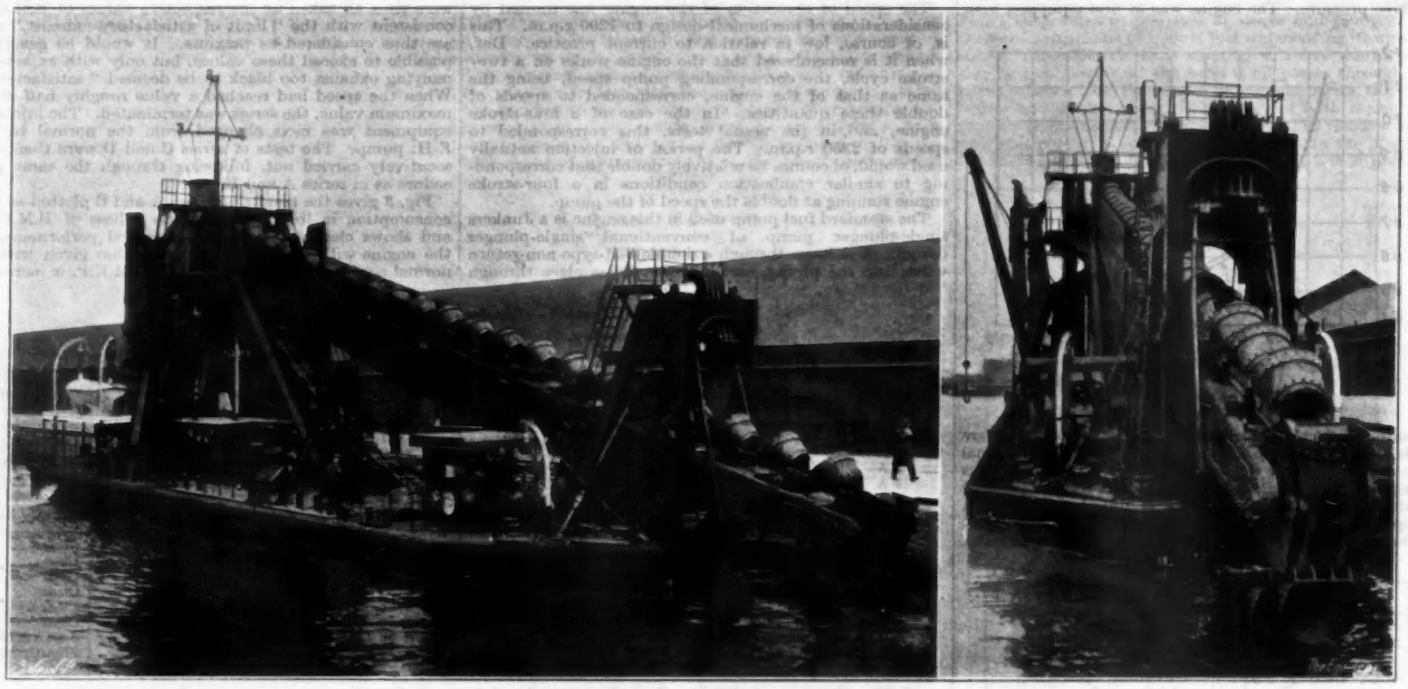

lie with the normal injection gear and be against the E-H. pump.

At the conclusion of series D some tests were made of the slow-running and manœuvring capabilities of the engine when fitted with the E-H. pump. The engine idled quite satisfactorily and steadily at 200 r.p.m. with a perfectly clear exhaust. It was possible, by working the pump controls, to accelerate rapidly from no load at low speeds to full load over a range of speed approaching 1200 r.p.m., and to decelerate again without obtaining exhaust conditions other than "satisfactory." This is admittedly more to be expected from an engine of this type in which a high compression pressure is combined with a rigorous and definite type of swirl than in most engines with indefinite turbulence; but it is, nevertheless, evidence of the effective manner in which the injection process is carried out at all speeds and loads.

In conclusion, it should be stated that this exceptionally good performance was realised at all speeds and loads with a smoothness of running and an absence of "knock" directly comparable with the running of the normal engine, which itself in this respect reaches a high standard. Summarising, then, I would state that these results can only be designated as extremely satisfactory.

I would like to express my thanks to Mr. F. L. Humphrey, B.Sc., a research student at King's College, who assisted me with the tests and in calculating the data.

Bucket Dredger for Thames Service.

THE bucket dredger "Tilbury II.," which was recently completed at the Port-Glasgow Yard of Ferguson Bros. (Port-Glasgow), Ltd., has been specially designed to the specifications of Mr. Asa Binns, M.I. Mech. E., Chief Engineer of the Port of London Authority, for work on the river Thames and in the Authority's docks. She is illustrated in the accompanying engraving, which shows two views of her in the Tilbury Dock, where, after a successful voyage round from the Clyde, very satisfactory dredging trials were recently carried out. The pontoon is strongly constructed, and has an overall length of 127ft. 10in., an overall breadth of 28ft. 4in., and a moulded depth of 9ft. 6in. As our illustrations indicate, the pontoon has a cut-away deck line at the bow for the purpose of enabling the dredger to work close up to quay walls. The buckets are each of 7½ cubic feet capacity and they are furnished with cutting lips of manganese steel. All the riveting on them, on the bucket ladder, and on the main and fore framings was carried out by hydraulic plant, and it conforms, we are informed, to the highest standard of riveted girder work. The height of the main framing has been so chosen that side shoots can be accommodated to enable the dredged spoil to be discharged at either side of the dredger into barges of varying sizes alongside. The dredger is of the non-propelling type and separate engines are provided for operating the bucket and for raising and lowering it. The main engines are of the compound condensing type and steam is supplied from a 140 lb. pressure coal-fired Scotch boiler. The engine-room auxiliaries include a feed heater with independent air, circulating, and feed pumps, the latter pumps being supplied by G. and J. Weir, Ltd. The whole of the main machinery was designed and supplied by the builders. The bucket ladder hoisting gear is of the worm wheel engine-driven type, and is neatly housed on the port side below deck on the vessel. The arrangement of the hoisting blocks and ropes and the ladder supports may be clearly seen in the two views reproduced.

The drive from the main engine to the top tumbler shaft is by two camel mohair belts, each 24in. wide, which were supplied by F. Reddaway and Co., Ltd., of Manchester. The top tumbler is made of manganese steel and the drive to it is effected by cast steel spur pinions and wheels. The deck auxiliaries include three powerful mooring winches, two forward and one aft, as well as the usual complement of bollards and fairleads. There is also a small crane for lifting or dismantling machinery parts. As shown in our illustrations, a boat and boat davits are provided, and there is cabin accommodation for the operating staff and the crew. The ship is fitted with electric lighting throughout, special deck standards being provided for night work. The generating set is by W. Sisson and Co., Ltd., of Gloucester.

The "Tilbury II." is the fifteenth vessel built by Ferguson Brothers for the Port of London Authority. She is designed to dredge to a depth of 45ft. below the water line and during the recent official trials her output considerably exceeded that specified.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE DOWSER'S ART.

SIR,—In these days, when the truth is being so passionately sought in many directions, your recent correspondence on this always controversial subject is of great interest. I recall that eminent mining engineer, the late Professor Le Neve Foster, always passed the subject over in his lectures by advising us to approach it with an open mind, thus treating it as "non proven," which is precisely where it remains to-day.

I have never seen the art in actual practice, but have frequently had its phenomena described to me by those who have, and, curiously, always in contradictory terms. Thus one would explain that the twig moved downwards with the wrists of the operator; another, that he held the ends of the Y and that the twig turned in the bearings formed by the forks of the hands twixt thumb and index finger—a more convincing statement—while a third assured me that the twig itself bent like a fishing rod—the most convincing of all, but which is correct?

There is just one other point. Do dowsers always work in dry weather and after the dew has dried up, for I confess it tests the credulity severely to believe in a twig which bows to hidden depths yet refuses to acknowledge a surface acquaintance? Why cannot a series of demonstrations be arranged over a horse trough, or do I blaspheme?

London, April 11th. S. P. CHRISTIE.

THE INTERNAL COMBUSTION ENGINE.

SIR,—The review of the above book published in last week's issue calls for some comment.

The statement that "Although little reference is made to State-aided research, it is a *fact* (italics mine) that the most important work on the theory and development of the engine is wholly or partly subsidised" has been written in utter ignorance of the facts and it is untrue. From my own personal experience and knowledge of what other men and companies have done during a period of about fifty years many, many thousands of pounds have been spent by them on the development of the internal combustion engine, and many of them would have refused State aid had it been offered to them. These men would not, of course, have called their work "research," the modern up-to-date name for experimental and test work.

The statement of your reviewer is only correct for the type of petrol engine used in flying craft, and as these were and are mainly used for naval and military work, State aid was both necessary and essential. However, the basis of the work of the State-aided "researchers" has been that of non-State-aided "experimenters," and advantage has been taken of their labours without even an acknowledgment.

Another statement: "It is in every case the efficient engines which stand the endurance tests best, whilst the troubles due to gummed-up rings and burnt-out valves are associated with the inefficient engines." Was it necessary to print this in a book costing fifteen shillings, as it is a fact which has been known to fitters, not to mention experimenters, for many years past?

Another statement: "More perhaps might have been made of the very important work done a generation ago by Dugald Clerk." What work? I know of none.

Finally, it is high time writers and reviewers of books should be a little more exact in their use of terms like "The Internal Combustion Engine," when they evidently largely refer to petrol engines only. The internal combustion engine covers a much larger and wider field than this. HUGH CAMPBELL.

Atlas Ironworks, Blackburn.

[Although we would be the last to deny the value of the work done by the makers of internal combustion engines, we must support our reviewer's opinion that the bulk of the work on the theory and development of the engine is now being done with money derived from other than manufacturing sources. It is hardly necessary for us to accept the challenge on behalf of Sir Dugald Clerk. His work enjoys world-wide recognition.—ED. THE E.]

BRITISH WATERWORKS ASSOCIATION.

THE twenty-first annual general meeting and conference of the British Waterworks Association will take the form of a summer meeting at Bournemouth, which will be held from June 21st to 25th, inclusive. The headquarters of the Association during the meeting will be at the Royal Bath Hotel, Bournemouth. On Tuesday, June 21st, a meeting of the Executive Committee will be held in the Town Hall, at 5 p.m. On Wednesday morning, at 11 a.m., the Mayor will welcome the delegates to the meeting at the Town Hall, after which the annual general meeting will be held. The presidential address will be delivered and the following paper will be read and discussed: "The Water Supply of Bournemouth," by Mr. Philip G. C. Moon. After luncheon the meeting will be resumed at 2.30 p.m. The following papers will be read and discussed:—"Some Observations on Water Supply Problems," illustrated by lantern slides, by Sir Alexander Houston, F.R.S.; and "The Fundamental Chemistry of Water Supply: How to Read an Analyst's Report," by Mr. J. H. Coste. In the evening a reception will be held in the Town Hall, and at 7.30 p.m. the annual dinner of the Association will take place.

On Thursday, June 23rd, the party will leave the Town Hall at 9.30 a.m. by motor coach, and will proceed for an inspection of the Bournemouth Waterworks at Alderney, Longham, and Wimborne. At 1.15 p.m. luncheon will be provided at the Town Hall, by invitation of the chairman and directors of the Bournemouth Gas and Water Company. After luncheon the party will leave the Town Hall by motor coach for an inspection of the Bournemouth Gasworks at Poole. Tea will be provided at the works. In the evening a reception will be held at the Town Hall by the Mayor and Mayoress, from 8.30 p.m. to midnight.

Friday, June 24th, will be devoted to a visit to Southampton. After luncheon, at 2 p.m., Mr. F. E. Wentworth-Sheilds, the Southern Railway Company's Docks Engineer, will give a short address on the new £13,000,000 dock works, and at 2.30 p.m. an inspection of the new dock works will be made.

Railway and Road Matters.

BLUE Book, Cmd. 4048, price 1s. 6d., recently issued, contains communications received by the Ministry of Transport from various undertakings as to their views on the report of the Royal Commission on Transport.

AT the annual general meeting of the Institution of Locomotive Engineers, held on March 31st, 1932, the following officers were elected for the session 1932–33: President: W. A. Lelean. Members of Council: J. W. Clubley Armstrong, H. Daly Atkinson, A. C. Carr, F. R. Collins, T. S. Finlayson, W. G. Hornett, W. F. McDermid, J. D. Rogers, S. H. Whitelegg.

IMPORTANT new railway work in India during the past fiscal year included the electrifying of the section Kalyan to Igatpuri of the Great Indian Peninsula Railway of 49 route miles of double track, which completed the main line electrification scheme, and the electrification of the Madras suburban section of the South Indian Railway, which was opened at the end of the year.

THE time table for the Folkestone-Dunkirk service, which, from May 1st, will replace the Tilbury-Dunkirk, has now been issued. The train will leave Victoria at 11 p.m. and the sea passage will occupy only 4¼ hours. The train will be due in Paris at 11.45 a.m., which is the hour at which third-class passengers at present arrive. Apparently there will no longer be the better facilities for first-class passengers, who now are due at 10 a.m.

ACCORDING to the report for the year 1930–31 of the Indian Railway Board, 573 miles of new railway were opened during that year; of this length, 306 miles were of the 5ft. 6in. gauge and 267 miles of metre gauge. The new lines sanctioned were 113 miles of 5ft. 6in. gauge and 55 of metre gauge, and at the end of the year 830 miles were under construction. The mileage of 5ft. 6in. gauge was 488; of metre gauge it was 201½, and the balance was of 2ft. 6in. or 2ft. gauge.

IN view of the development, for industrial and residential purposes, of the area between North Acton and Northolt, the Great Western is improving the train services between Northolt and Greenford on the one hand, and North Acton and Ealing Broadway on the other. A siding, to be provided at the latter place, will allow the steam car services from Northolt *vid* the Greenford loop to run to Ealing Broadway and make exchanges with the important services available at that station.

THE record for operating the longest non-stop freight service in the country is claimed by the L.M.S. Railway, whose 7.45 p.m. express freight train from London (Camden) to Liverpool (Edge Hill) covers the 191 miles between these centres without an intermediate stop. The greatest distance covered by a through express freight train on the L.M.S. is 545 miles from Aberdeen to London (Broad-street), the 9.35 a.m. express freight train from Aberdeen arriving at the London terminal at 11.25 p.m. the same day. The longest freight service provided by the L.M.S. in through wagons is between Thurso and Bournemouth, a distance of more than 850 miles.

SOME time ago we noticed how the London, Midland and Scottish Company had followed, at Finchley-road, the example of the Southern Railway at Putney and were building some shops at the point where the high road crosses the railway. THE ENGINEER drew attention to this, and that may have inspired the L.M.S. action. According to a recent official statement of the L.M.S. Company, not only has the work at Finchley-road been completed, but similar undertakings have been finished at Watford, Wembley, Walthamstow, and Upton Park, whilst progress has been made with such schemes at Kilburn, East Ham, and Walsall. As the notice says, the street adjacent to the railway station is often the principal shopping centre of the locality, and thus valuable frontages have hitherto gone a-begging.

THE anomaly that the "Flying Scotsman," by the East Coast route, when running non-stop, in the summer, between King's Cross and Edinburgh, was given the same 8¼ hours as it required, with four intermediate stops, in the winter, has long been the subject of public comment. Mr. Whitelaw, the chairman of the London and North-Eastern Railway, explained, at the last annual meeting, that it was a consequence of an old-standing agreement with their competitors, which was, however, then under review. The discussions thus referred to have evidently now been completed, as it is officially announced that, as from May 2nd the present limit of all the Scottish expresses will be reduced from the present 8 hours 15 minutes—8 hours 30 minutes to 7 hours 50 minutes—8 hours, and that when the non-stop runs are re-introduced with the summer services the "Flying Scotsman" will be given 7 hours 30 minutes and the L.M.S. "Royal Scot" 7 hours 40 minutes. The shorter time for the former is evidently a concession to its 8 miles' less distance. An agreement made between the Great Northern and Midland, in the middle 'eighties, that the former would not run non-stop between King's Cross and Leeds is also terminated.

SINCE, in our issue of March 18th, we commented on the apparent rarity with which accidents occurred owing to the failure of signals there has appeared another accident report in which, again, signals are concerned. Here it was not a question of signal failure, but rather of the irregular action of a signal fitter. The mishap in question occurred on December 14th last, and was a case of a passenger train at Holloway, London and North-Eastern Railway, coming into sidelong collision with a goods train which, with "clear" signals, was passing through a cross-over road from the up goods line on to the up slow line. The passenger train was on the latter line and its home signal was at "danger" when the train approached it. The train stood at the signal for about one minute and it was then put to "clear." The driver thereupon gave his engine steam and the collision ensued. The reason for this irregularity appeared, according to the report of Colonel Trench, who inquired into the accident, to have been due to the wire of the signal having broken earlier in the morning. It was temporarily repaired and, later, all was made correct by the signal linesman. In testing that the signal was working properly that man evidently moved the arm and, by accident, did so sufficiently far as to put the arm to "clear."

Notes and Memoranda.

THE length of concrete roads—reduced to a standard width of 20ft.—laid in Great Britain and Ireland, has increased from 182 miles in 1926 to 1540 miles at the end of 1931.

IN Oregon the employment of hand labour for the construction of roads has been dropped, although it was organised with the object of reducing unemployment. It has been found, according to American advices, that the cost of hand-made roads is about eight times that of roads on which modern mechanical devices have been fully utilised.

ACCORDING to Mr. R. S. Pilcher, the general manager of the Manchester Corporation transport department, the adoption of heavy oil engines for the motor omnibuses has resulted in a saving in fuel costs of 2d. a mile. The vehicles have been tested extensively on routes as long as 202 miles a day, and it is said that the drivers prefer them to those equipped with petrol engines.

STATISTICS collected during the construction of the Sukkur Barrage in India show that in excavating canals by means of drag-lines the costs, with steam driven machines, ranged about 3·5d. per cubic yard, while with oil-driven machines they were about 2·6d. per yard. In some cases, however, the costs have been as low as 2·2d. for a steam-driven and 1·21d. for an oil-driven set.

A NOTE in the *Iron Age* states that an American manufacturer of electrical equipment was recently faced with the problem of machining a nitrided steel part. He placed the piece in a sodium potassium chloride salt bath maintained at about 1500 deg. Fah., and then, after allowing it to cool slowly, he was able to machine it and afterwards to re-nitride it to give it its original surface hardness.

THE Missouri–Kansas–Texas Railroad Company's new bridge crossing the Missouri River at Boonville, Mo., was completed in January, and the contractor, the Kansas City Bridge Company, has been engaged in demolishing the adjacent old bridge, the piers of which were built in 1874. Included in the five-span crossing is a 408ft. lift span, weighing 1150 tons, said to be the longest railway lift span yet built.

BRITISH Columbia has produced some notable flag poles. The one at Kew Gardens, London, is 241ft. high. One exhibited at the Canadian National Exhibition in Toronto was 177ft., a giant of the forest 236 years old. The one for the University of British Columbia is 204ft. from base to tip, tapering from 47in. to 14in. and containing 4070ft. of lumber. The flag pole at the Vancouver Courthouse is 201ft. high.

ACCORDING to a report from Paris, a mixture of sugar and water is making a name for itself as a substitute for lubricating oil. A Belgian representative at a meeting of the International Sugar Council recently held in Paris stated that a solution of 60 per cent. sugar and 40 per cent. water had been used experimentally for a week at one of the factories of the Raffinerie Tirlemontoise, in Belgium, and had proved adaptable as a lubricant.

WORK is proceeding apace, says the *South African Mining and Engineering Journal*, in connection with the construction of the Lower Zambesi Bridge, now being carried out by the Cleveland Bridge and Engineering Company, Ltd., of Darlington. Although, so far, there are few outward and visible signs of the bridge itself, the enormous amount of preparatory work necessary as a preliminary to the construction of the bridge is well advanced, and is indicated by a complete unit of a powerful well sinking set, moored in the river, and the erection of cranes and other machinery at the sites of some of the piers on the low bank on the Sena side. The building of the many barges for the transport of materials is progressing, and one of the light-draught steamers sent out from England in sections has been launched and equipped with a powerful boiler.

SOUND concrete, said Mr. G. McLean Gibson, in an address to the Manchester and District Association of the Institution of Civil Engineers, is not harmed by freezing, even if it is soaked with water. If the concrete is porous, or a crack appears, which permits liquid water to enter and freeze, the pressure of ice formed increases the width and depth of the crack, until disintegration eventually takes place. Concrete should therefore be well covered up if there is any risk of frost. All cold weather delays the hardening of cement, but it is possible to lay concrete with the temperature at 35 deg. Fah., provided due precautions are taken that the aggregate is not frozen and the work is covered up and properly protected until the concrete has hardened. Any complaint in winter time regarding the slow setting of the cement is invariably found to be due to the low temperature.

IN a paper describing developments in Electrically Welded Fabrication, read before the Junior Institution of Engineers on April 1st, Mr. E. P. S. Gardner emphasised the necessity for designing steel structures with due regard to the method by which the various members were to be joined, whereby considerable economies in the weight of steel used could be effected, and stressed the advantages, in this respect, of the monobloc type of structure as against jointed construction. The necessity for educating draughtsmen and designers in the practical application of electric welding was pointed out, inasmuch as a design for a steel fabrication should show the preparation of the plates, the number of separate runs of welding metal to be applied, the gauge of the electrodes to be used and the procedure to be adopted during welding. There were now tables available which gave the necessary information. In regard to the frequent inquiry as to the training of welding operators and the allegation that it was necessary to employ highly skilled and experienced operators, the lecturer stated that a differentiation must be made between the welding engineer and the welder; a simple operator need not have engineering experience, but the welding engineer must be a trained man. Further, an operator employed by a firm of general welding contractors must have had experience in the welding of several types of structures and engineering plant, but the work to be done by a structural steelwork operator did not demand that varied knowledge.

Miscellanea.

H.M. SUBMARINE "M 3," the last of the "M" class, is to be broken up.

IT is proposed to put up an oil refinery in Montreal East at a cost of 1,000,000 dollars.

THERE is a hint in *Indian Engineering* that the city of Bhusawal may be supplied with electricity.

PORTRUSH, in the North of Ireland, is to be developed as a fishing port, and already several trawlers are working from that base.

A MILL for the production of 200 tons of bleached paper pulp daily is to be put up at Seal Cove, Prince Rupert, British Columbia.

THE French Post Office is adopting three-wheeled motor carriers for the collection and delivery of letters in Paris, Lyons, and Marseilles.

IT is reported that diamonds have been discovered in the limestone formation near Coega, in the Port Elizabeth district of South Africa.

THE Montreal Locomotive Works, Quebec, proposes to adopt the manufacture of "self-propelled rail units," in accordance with the specifications of the J. G. Brill Company, of Philadelphia.

IT is announced that Sir Charles Hipwood, the second Principal Secretary to the Board of Trade, is resigning his office and is taking up the position of director of the National Union of Manufacturers, in succession to the late Sir John Corcoran.

THE cable tunnel for the Calcutta Electric Supply Corporation, Ltd., under the river Hooghly—the construction of which began two years ago—has now been completed and one can now walk under the river bed from Calcutta to Howrah.

THE extension of the south breakwater to protect ships entering the harbour at Durban, Natal, has been completed after more than three years' work at an estimated cost of approximately £174,000. The work has required the laying of 2407 blocks having a total weight of 72,000 tons.

A NEW broadcasting station is to be put up at Buenos Aires by the Marconi Company. It will incorporate all the latest developments in the design of broadcasting transmitters, including crystal and valve frequency control and low-power modulation. With a power of 20 kW it will serve a large area round Buenos Aires.

WORK is about to be started on the new bridge across the Buffalo River at East London, South Africa. It is claimed that it will be the largest double-deck river bridge in the country. It will have a span of approximately 1000ft. and will cost £114,000. The upper deck will carry a road for vehicular traffic and footpaths for pedestrians; the lower will be used for trains and will also carry the municipal water mains and electric cables. The existing bridge was built in 1904.

OF the 73,000,000 lb. of nickel consumed throughout the world in 1931, the International Nickel Company of Canada supplied some 55,739,000 lb. The company's output of platinum metals from the precious metal refinery at Acton, London, England, increased quite notably. The output of platinum metals in 1931 was 91,644 oz., compared with 71,260 oz. in 1930, an increase of 22 per cent. Platinum production was 44,725 oz., compared with 36,806 oz. in 1930. The other metals in the platinum group produced by International Nickel are palladium, iridium, rhodium, ruthenium, and osmium.

THE official returns rendered to the Electricity Commissioners show that 1090 million units of electricity were generated by authorised undertakers in Great Britain during the month of March 1932, as compared with the revised figure of 1038 million units in the corresponding month of 1931, or an increase of 5 per cent. During the first three months of 1932 up to the end of March, the total amount of electricity generated by authorised undertakers was 3385 million units, as compared with the revised figure of 3193 million units for the corresponding period of 1931, representing an increase of 6 per cent.

AFTER three years' work and more the extension of the south breakwater to protect ships entering the Durban harbour was practically completed last month at an estimated cost of approximately £174,000. S.A.R. engineers will continue to make observations of the settlement of the new construction at regular intervals and after heavy storms. The new pierhead proved its stability in the recent heavy weather, seas breaking over it continually for thirty-six hours and causing no damage. Altogether 2407 blocks, weighing 72,000 tons, were dumped into the sea to form this breakwater. It will be opened formally next month.

ACCORDING to the National Federation of Iron and Steel Manufacturers, there were seventy-two blast-furnaces in operation at the end of March, a net increase of one since the beginning of the month, one furnace having ceased operations and two having been blown in. The production of pig iron in March amounted to 335,600 tons, compared with 323,600 tons in February and 357,100 tons in March, 1931. The production included 65,800 tons of hematite, 133,000 tons of basic, 114,100 tons of foundry and 14,200 tons of forge pig iron. The output of steel ingots and castings amounted to 462,800 tons, compared with 480,600 tons in February, and 500,100 tons in March, 1931.

A VESSEL which has just been launched from the yard of Canadian Vickers, Ltd., of Montreal, is of a rather exceptional type. She has been specially built for putting in place the steel and concrete water intake pipes for Toronto, each section of which will weigh 250 tons. The vessel will be electrically driven throughout, primary power being supplied by twin Atlas-Diesel engines of 200 horse-power each, connected directly with 220-volt, D.C. generators. The new derrick boat was designed by the engineering staff of the Foundation Company of Canada, Ltd., and has a length of 100ft., width of 42ft., and moulded depth of 11½ft. Twin sheerlegs at the stern will each take 150 tons lift, and on the top of the derrick house there is a revolving crane with a capacity of 30 tons.

ELECTRICAL EQUIPMENT AT THE MOUNT ISA MINES, QUEENSLAND

THE GENERAL ELECTRIC COMPANY, LTD., LONDON, ENGINEERS

(*For description see page* 415)

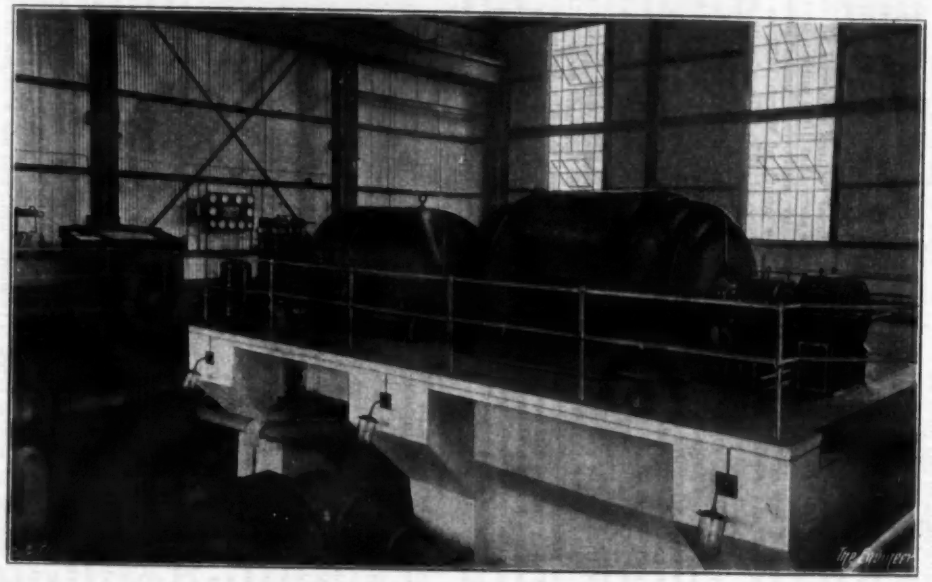

FIG. 7—5000-kW TURBO-GENERATOR SET

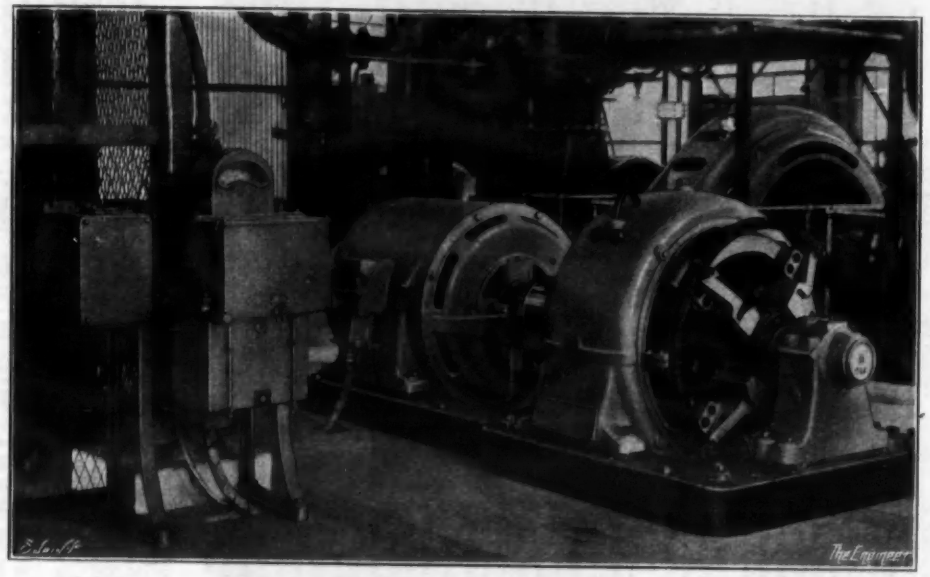

FIG. 8—MOTOR GENERATOR SUPPLYING UNDERGROUND LOCOMOTIVES

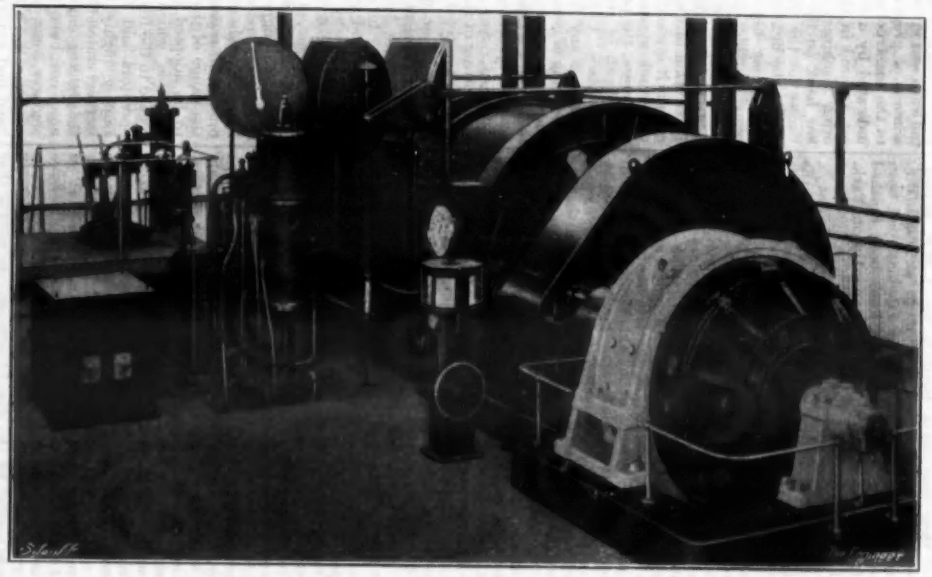

FIG. 9—1525 H.P. ELECTRIC WINDER FOR ORE HOIST

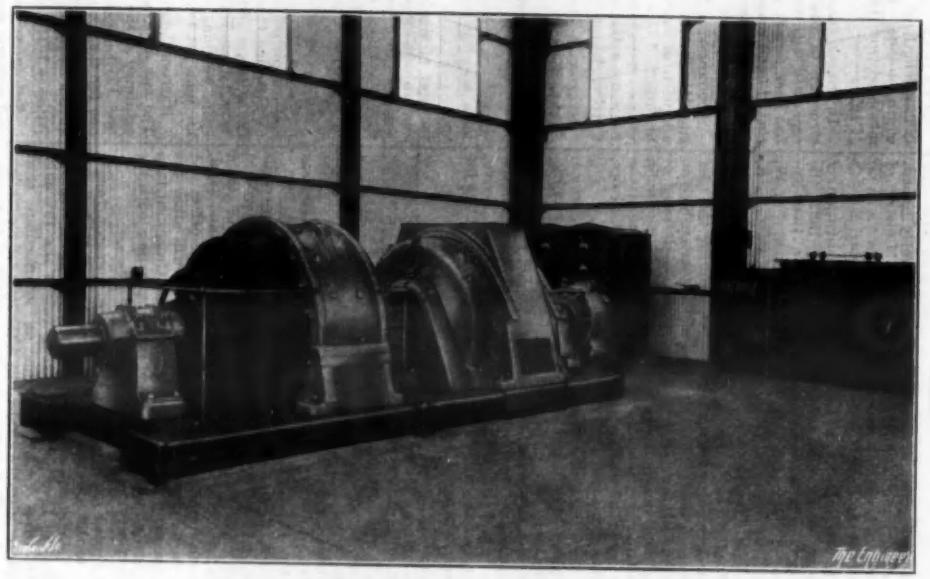

FIG. 10—1100-kW WARD-LEONARD SET FOR ORE HOIST

The Engineer

APRIL 15, 1932.

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THE ACCURACY OF GEAR WHEEL TEETH.

THE paper on the performance of gear wheels by Messrs. Hyde, Tomlinson and Allan, presented last week before the Institution of Automobile Engineers, and reproduced elsewhere in this issue, undoubtedly suggests, on cursory study, that much of the effort spent on obtaining refined accuracy of dimension or shape in certain engineering details may be fundamentally superfluous and, possibly, even undesirable. By modern grinding processes gear wheels can now be produced commercially with errors in their pitch, profile and other dimensions not exceeding one, or, at the most, two ten-thousandths of an inch. Principally, but by no means exclusively, in the motor car industry these super-accurate gear wheels are now very widely used. It would seem to be unnecessary at this date to discuss the reasons why they have found favour; the advantages of high accuracy in gear wheels appear to be thoroughly obvious. After he has studied the paper above referred to, the reader will, however, scarcely fail to be assailed by some doubt as to why precisely high accuracy is advantageous. The design of gear wheels is, or is generally held to be, primarily a geometrical problem. The mathematicians long ago laid down the general rule which must be followed in order to obtain constancy in the velocity transmission ratio, and within the limits of that rule various forms of tooth profile have, from time to time, been evolved with the objects of facilitating manufacture, of obtaining the maximum amount of rolling and the minimum amount of sliding action between the contacting teeth surfaces, and of increasing the strength of the teeth. The geometrical requirements having been established, it would appear obvious that the more nearly the actual gear wheel reproduces the desired geometrical form the better and more satisfactory will the wheel be. That, in effect, is the argument behind the effort to achieve high accuracy in gear wheels. It is an incomplete argument. A gear wheel, as it leaves the cutting or grinding machine, may, in essence, be a geometrical figure, but when it is put into service with a mate it becomes a machine. Its form is not inflexible, but is modified by the stresses which the wheel has to bear and transmit. The satisfactory behaviour of the wheel will, therefore, be determined, not solely by the accuracy with which it reproduces the "correct" geometrical form, but in part—apparently in a surprisingly large part—by the manner in which, and the extent to which, that form is modified in service.

Let us imagine that we have two gear wheels, each of which is geometrically accurate to the utmost limit of measurement. If these two wheels are meshed together the transmission of power through them will at once destroy the geometrical perfection of their form. Under load the teeth in engagement will deflect or deform and, as a consequence, the geometrical accuracy of their profiles and pitches becomes less than perfect. To what extent this effect will modify the action of the wheels can hardly be investigated theoretically. The problem is clearly a very complex one, involving not only the elastic properties of the material of which the wheels are formed, but the load transmitted and its constancy or variability, the speed of the transmission, the number of teeth in the wheels, and—not least—the inertia of the parts transmitting the motion. We may picture something of the action which occurs by supposing that the wheels possess an exaggerated amount of inertia and are formed of a highly flexible material. In these circumstances, the contacting tooth on the driver will be deflected backwards, thereby shortening the pitch between it and the next driving tooth to come into engagement. On the driven wheel the contacting tooth will be pressed forward, thereby lengthening the pitch between it and the succeeding tooth. A pitch less than the geometrically perfect pitch is, therefore, called upon to engage with one which is greater than the perfect pitch. As a result, the two succeeding teeth come into engagement in an imperfect manner. In practice, the action is not quite so simple as we have indicated, for factors involving the relative acceleration and deceleration of the wheels have to be taken into consideration. The net result is, however, that the geometrically perfect wheel ceases to be geometrically perfect when it is under load. That being so, it follows that a wheel initially imperfect to some particular degree may give better results in service than one initially perfect. Evidence to that effect will be found in the paper. For example, we may direct attention to the experiments made on the efficiency of a pair of wheels when set with their centres at the "correct" distance apart, at one-hundredth of an inch short of that distance, and at two and four-hundredths of an inch greater than it. As the distance apart of the centres was made less than the correct value the efficiency fell off, but as it was made greater—corresponding, in effect, to an increase in the pitch—it definitely rose. That the action which we have described is not one affecting merely the efficiency of the transmission in the first or second places of decimals should be clearly noted. Were it so, it would be a subject, almost purely, of academic interest. It seems fairly certain that it is at the root of several obscure defects in the behaviour of apparently correct gear wheels. The impact stresses thrown upon the teeth as a result of their deflection under load would appear to be out of all proportion to the magnitude of the deflection. Wheels with certain of their teeth deliberately made with a pitch error comparable with the deflection estimated to occur in the teeth of a normal wheel in service broke by fatigue under a ridiculously low nominal load—3 per cent. of the ultimate static breaking strength. The inference clearly is that the nominal load is not a real measure of the true value of the impact stresses thrown upon the teeth by their very slight departure from perfection. That the subject is one of direct practical importance is borne out by an interesting fact mentioned by Mr. Arthur Orcutt during the discussion on the paper. Mr. Orcutt stated that his company is now grinding gear wheels for aircraft engines with the teeth actually distorted in order that when they are under load they may have the correct form. Failures had occurred with the ordinary teeth, but since the distorted teeth were adopted there has not been a single failure. It should be noted that the gear wheels of aero engines are exceptional in two respects. In the first place, they are loaded very highly, to as much as 4000 lb. per inch of face width, and are therefore particularly open to the defects produced by tooth distortion. Secondly, unlike the gear wheels of, say, a motor car, they run under a substantially steady load, and are therefore favourably circumstanced as regards the correction of those defects by the deliberate distortion of the unloaded teeth. If the load on a pair of wheels is variable the tooth deflection will be variable, and therefore a given amount of initial distortion will suit only a restricted range of the load.

Reviewing the situation, we see that the facts revealed by the experiments at the N.P.L. do not really imply that the efforts to obtain refined accuracy in the teeth of gear wheels are superfluous. Actually, they seem to us to emphasise the necessity for still farther efforts towards increasing the accuracy of form. Two reasons are apparent. First, inaccuracy of manufacture may be in the direction required to counteract the defects produced by the deflection of the teeth under load. Equally well it may be in the opposite direction. The fact that in the first case the inaccuracy of production is actually favourable to the performance of the wheels cannot be held to compensate for the uncertainty which must prevail as to the direction in which the inaccuracy will act in a pair of wheels taken from stock. Secondly, in spite of the magnitude of the results which it produces, the deflection of the teeth under load is, it would seem, of the same order of size as the limit of error to which ground gear wheels are now produced commercially. If, therefore, the defects produced by the deflection of the teeth under load are to be counteracted by the initial unloaded distortion of the teeth, the satisfactory realisation of the correct amount of distortion must demand still greater efforts towards the achievement of accuracy.

Feed Water.

PRESENTING a paper on "The Conditioning of Boiler Feed Water" to the Institute of Fuel at Nottingham on Friday last, Mr. V. B. Harley-Mason said that the subject was so hackneyed that nothing remained to be said about it. We may be thankful that he was not deterred by that consideration, for, after all, he succeeded in producing a paper of considerable interest in itself as a general review of the position of feed water treatment to-day, and particularly to be commended as a presentation of the subject suitable for the limited digestion of those boiler attendants who have not had the time or opportunity to study the matter fully. When it is recalled that only a small proportion of the steam boilers and similar vessels in which scale may form are in charge of fully qualified men and that scale is both a cause of loss of economy and a positive danger, the value of such a simple discussion as this will be appreciated. Whether the greater number of boiler failures which fall under the Boiler Explosion Acts occur under what may be regarded as technical supervision or under no proper supervision at all we cannot say, but it has been shown over and over again that lack of knowledge of the elemental principles of boiler management is a fruitful source of trouble and of even fatal accidents. The fact that expert supervision sometimes nods is no argument at all against the expansion of sound information about the phenomena of boiler operation, amongst which that of scale deposition occupies an important place.

Mr. Harley-Mason was rightly severe in condemnation of the boiler quack, and remarked in that connection that "the curing of boiler ills is in fact so similar to the curing of human ills that it is a pity the practice and profession of water treatment cannot be put on the same basis as the practice and profession of medicine, where there are definite recognised standards of professional qualifications and procedure." The obvious comment on that ingenious suggestion is that many capable advisers exist, but just as people with bodily ills take the advice of "old wives" or destroy their systems with quack nostrums, so there are many boiler attendants, and even boiler owners, who rather than seek the advice of such bodies as that which Mr. Harley-Mason represents or of reputable makers of water softening plant, are led into useless and sometimes dangerous experiments by the plausible tongues of irresponsible salesmen. May we suggest that the object which Mr. Harley-Mason had in view would be better served by the prohibition of the sale of useless or dangerous boiler compounds than by an extension of the number of "doctors." If every boiler compound had to bear the certificate of some recognised testing authority the days of the "quack" would be numbered. We fancy, however, that change of methods and the wider expansion of knowledge, in which such bodies as the Institute of Fuel play an important part, is undermining the activities of the unqualified practitioner. The scientific treatment of boiler waters is now far more common than it was, and it is the exception rather than the rule to find boiler owners of any moment who have not taken the opinion of competent chemists on

the appropriate method of conditioning their feed waters. Unfortunately, conditions sometimes leave no choice but to treat the water in the boiler itself. That is, beyond all doubt, not the right place to carry out a chemical operation; the boiler is a steam generator, not a laboratory. The best modern practice is the purification of the water before it enters the feed tank. Even the railways, which are faced by peculiar difficulties in that connection owing to the many centres at which water cranes must be available and the great diversity in the quality of the water itself, are now rapidly adopting external purification on a large scale. Any time that can be saved from the hours which an engine is off duty—as in this case for washing-out—means a reduction in the necessary stock of locomotives and therefore, apart altogether from technical considerations concerning the relative efficiency and longevity of clean and dirty boilers, the economy of softening the water before it enters the tenders is being found to justify the expenditure upon the plant.

As we have said, times have changed. The tank boiler of any type would tolerate conditions which are quite unbearable in the water-tube boiler, and with the continued development of the latter we may expect to see wider and wider recognition of the rule that no boiler should ever be fed with unsuitable water. That rule cannot, we admit, be universally applied. But if it is, as it must be, recognised as sound, we may fairly expect that where circumstances prevent its application the only alternative, proper treatment of the feed water under expert chemical advice, will be practised.

The Position of Industry.

Excerpts from the address of the retiring President, Sir James Lithgow, to the Federation of British Industries on April 13th.

I REGARD the fiscal question as now clearly outside the political arena. A further change of policy is quite unthinkable until our new system has had time to justify itself. Argument thereon can now only retard recovery by causing a feeling of uncertainty. For better or for worse the operation has now been performed. A long and painful convalescence is inevitable. Patience and encouragement are necessary and can be justly demanded, especially of those who by their advice have been instrumental in the operation being so dangerously postponed.

The responsibility for the proper use of our new system now rests upon those engaged in industry. To be fully successful it must be loyally supported by those who plan, by those who direct, and by those who carry out every operation of production.

If this country is to retain a standard of comfort for its people superior to that of our competitors, we must all understand that such a result can only be obtained by maintaining a higher state of efficiency than that of our competitors.

Now that we have to meet other nations whose technique and skill have become fully developed, this greater efficiency can be obtained only by the most intensive application throughout the whole field of the nation's activities.

Efficiently planned and well-managed plants, manned by willing and energetic workers, must be supported by ancillary services operating with equal efficiency. National policy must be so directed as to permit of these operations being carried out under conditions which make maximum efficiency possible.

Purchase in the cheapest market of the materials required for our industrial operations and for the consumption of our people was the most efficient national policy so long as the resultant savings were reflected in the costs of our own manufactures, and so long as we were able to sell our products in satisfactory quantity in the markets of the world. Since domestic policy, through standardisation of emoluments and national burdens, has brought about a rigidity in our economics which prevents these cheap purchases being fully reflected in our manufacturing costs, and since international policy has closed many of the markets of the world to us, it is no longer possible for us to sell our goods in satisfactory quantity indiscriminately throughout the world.

In these circumstances the nation has realised that it is necessary to change our national policy so as to protect the products of our own industry from the competition offered to them by competitors unhampered by our burdens and unbound by our efforts to maintain a higher standard for our people.

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Our national policy, especially of recent years, has in my view, laid too much emphasis on the position and protection of the consumer and the non-producer. Much of our legislation which has the effect of restricting the output and increasing the costs of our factories and works is founded on isolated instances of abuse or on opinions condemnatory of industrial methods, formed by persons in authoritative positions who are imperfectly acquainted with the circumstances and the difficulties of producing goods which must be sold in the markets of the world.

* * * *

The change in our fiscal system will, I believe, have the important effect of changing the attitude of our public services towards industry. The attention of many of the best minds in the country who fill our highest administrative posts has been engaged upon the rather sterile task of seeking out how they can protect the careless and the unfortunate, which, when carried to extremes, means how they can hamper and burden production. The real appreciation of the needs of industry necessary for the administration of a satisfactory protective policy will open to them the far more constructive field of supporting capitalists in their real function of giving work and wages.

It is indeed difficult for me to understand why the extending of the field of employment, which should be the first duty of those possessing enterprise and wealth, should occupy such a secondary place in the imagination of our administrators, and why the provision of this employment should be looked upon as a boon only if its conditions pass the standards of the monopolists and the theorist; standards which in many cases are so economically artificial as to impose a crippling burden on our export trade.

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It cannot be over-emphasised that without a flourishing export trade even the whole home market cannot possibly maintain a country like Britain, dependent for its food and its raw materials upon imports from overseas.

I have referred to the need for patience and encouragement for our sorely tried basic industries. I have pointed out the danger of administrative zeal in the fatal direction of using the protective system as an excuse for uneconomic and enervating restrictions, and I have emphasised the heavy responsibility upon industrial leaders to use protection, not as a shelter but as a foundation on which to build and develop a world competitive production.

These considerations lead me to lay stress upon the need of co-operation, one industry with another. If those industries which are protected seek to exploit sister industries which are their customers, the whole basis of our new system will fail. Similarly, if those industries to which foreign goods are still available carelessly fail to support home producers from whom they would naturally draw their supplies, they merely give point to agitation for further tariffs. It is the duty of organised industry to guide national policy along lines of security and stability rather than to promote agitation and uncertainty.

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Industrial development is dependent upon a plentiful supply of capital, derived, not only from those who actually conduct industry, but also from the general public.

Investors must believe that industrial adventure is likely to succeed and that, however poor the return of the immediate past or the present may be, a brighter future will wipe out present losses and produce profits commensurate with the risk. Such belief is an essential of that confidence which alone makes capital available to any enterprise under any system.

It is sometimes overlooked that low rates of interest payable each year and even Government guarantees do not permit industrial operations to be carried on indefinitely at a loss.

The cost of public extravagance, falling, as it has, for the most part on the shoulders of those who have devoted their energies or their capital to our heavy industries, has given rise to the fear that the future holds out no hope of reward to these investors, and has created feelings dangerously approaching to resentment at the penal nature of the taxation which has been imposed. So long as direct taxation is permitted to remain at anything approaching its present level, faith and hope rather than gratitude must be our attitude to a Chancellor grappling with a tremendous task.

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Expansion of expenditure has been stopped—a great achievement. Severe curtailment of purchases is being enforced, but it is impossible to feel confident from the published returns that a real change of heart has been effected in the minds of those who conceive their function to be to regulate rather than to govern.

The task before this country, if it is to enable its industry to reap the full benefit of the new policies already laid down, is to bring about such a change of heart.

The aim of good government must be to stimulate every section of the people to do the maximum for themselves rather than to lean upon the State. Industry can do much to strengthen the hand of an administration which adopts that aim.

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I am fully aware that no matter how perfect our domestic organisation nor how suitable our national policy, prosperity cannot return to Britain until the trade of the world revives again.

I have confined my review to British affairs, because these are matters which it is within our own power alone to regulate, and also because I believe that our power to influence international affairs vitally depends upon the possession of a vigorous and healthy national policy which will enable us to enter the councils of the world with a force and an authority which in recent years we have not possessed.

No review of British industrial conditions, however, would be complete without reference to the subject of Imperial co-operation upon which your Federation in recent years has laid such stress.

We are conscious that considerations of patriotic attachment to the Mother Country play an important part in the readiness of the Dominions to stand by Great Britain in times of difficulty; but we also know that the various sections of the British Commonwealth are fully alive to the fact that their full development and prosperity require as their foundations a prosperous Empire based upon a sound Mother Country and that they have a duty to themselves to help in the common effort.

Past misunderstandings and divergence of ideals have made the task of fiscal co-operation difficult. However, circumstances seem to have conspired to make the present propitious for a renewal of efforts to establish an Empire economic policy, the keynote of which will be the welfare of the Empire. The Federation of British Industries has played an important part in developing this idea.

The personal and direct contact which, as your representative, I have had with the subject of Empire co-operation, notably in connection with your mission to Canada last year, has been illuminating. It has deepened my appreciation of the serious obstacles which honest difference of viewpoint and long established interests and associations offer to the consummation of the ideal of an Empire correlated as one industrial unit; after all, the task of overcoming these difficulties only differs in degree from the similar task of organising on a rational basis some of the older established industries in Great Britain itself. This necessary task is, we believe, within the power of enlightened leaders making mutual concessions for the common good.

While the influence of a well-equipped Britain on the recovery and expansion of world trade is indeed great, the influence of the British Empire, speaking with one voice and acting with one purpose, must indeed be incalculable.

I believe a prosperous Britain is essential to a prosperous British Empire. I believe a prosperous British Empire is the key to world prosperity.

The difficulties before us, both of our own making and thrust upon us by outside influences, are immense and have been accumulating for nearly a generation. We can now say with confidence that the tide is turning; a new hope is awakening. Meantime, perhaps, it is in spirit only that we find our burdens lighter and the air clearer. If, however, we take advantage of this stimulus to repair bit by bit our own defective fabric, and in co-operation with the other parts of the Empire build up an even more imposing edifice of trading power, we shall find that when world trade revives we are able to re-engage in it with equity and goodwill, strengthened, not weakened, by the fact that we have placed Empire first.

Literature.

Witwatersrand Mining Practice. By G. A. WATERMEYER and S. N. HOFFENBERG. Johannesburg: Hortors Ltd. 1932. Price 45s.

IT may at once be said that this book is on the whole a very good piece of work within the limits which the authors have set for themselves, as is, indeed, but natural, seeing that the one is the Professor of Mining and the other the Senior Lecturer in Mining in the University of the Witwatersrand. The book, further, carries a short foreword by the President of the Transvaal Chamber of Mines, so that it may be looked upon as being in some sense an authoritative publication. Its main defect is that the authors do not appear to have made up their minds exactly to what section of the public they are addressing themselves, some portions being too elementary to be of use to anybody except a school-boy, whilst other parts could be of use only to the already experienced mining engineer.

Whilst the main appeal of the book will necessarily be to those engaged in the work of mining on the Witwatersrand, it has a wider interest, inasmuch as it may be said to represent the best modern mining practice in deposits of this type. The district is unique in its production of an enormous output of gold from a relatively small area, and the extraordinary wealth thus produced has made it possible for the groups engaged in mining this area to engage the services of the very ablest men in the world, both in technical engineering and in economics. Hence no one interested in mining technology can fail to be interested in the descriptions to be found within this volume.

The authors correctly state that whilst Professor Trustcott's book on "Mining Practice in the Witwatersrand Goldfields," was issued some thirty years ago, the industry has so greatly developed, and has so completely changed its aspect since then, that a new work describing the present state of affairs was really urgently needed. It should, however, be pointed out that the scope of this volume and of

Professor Truscott's are not quite the same, because the present is confined to the Witwatersrand proper, whereas in Professor Truscott's book, to use his own words, "The term Witwatersrand Goldfields is taken to include all the goldfields, amongst others the Witwatersrand, Klerksdorp, Krugersdorp, Ventersdorp, and Heidelberg goldfields, which have been proclaimed by the South African Republic, to cover all the occurrences of auriferous banket on which prospecting work or exploitation has been carried on." The ground covered by the present authors is perhaps best seen by a list of the chapters into which it is divided, namely:—I., History of the Gold Industry of the Rand; II., Geology of the Witwatersrand; III., Prospecting; IV., Mining Appliances for Breaking Ground; V., Shafts; VI., Lay-out of Shaft Stations and Development; VII., Stoping; VIII., Support of Underground Workings; IX., Underground Transport; X., Winding Machinery; XI., Mine Drainage and Pumping; XII., Ventilation; XIII., Sanitation and Health; XIV., Labour; XV., Accidents and their Prevention; XVI., Legislation; XVII., Illumination; XVIII, Mine Surveying; XIX., Mining Economics; XX., Mine Accounts. These chapters are of very unequal length and of unequal quality; some of them have been written by people other than the authors named on the title-page, and no doubt this fact accounts for a certain amount of duplication and for occasional discrepancies which will be noticed by the careful reader.

Perhaps the main fault to be found in the book as a whole is that the authors have either deliberately ignored or else are ignorant of modern practice outside the Transvaal; for example, in the chapter on Mine Surveying, levelling and levels are described at some length, but the authors confine themselves to the Wye and Dumpy levels, and make no mention of modern levels of precision, such as the Zeiss, which are in general use among engineers to-day. Again, considerable fault may be found with the looseness of the authors' definition of normal and reverse faults. Apparently, they call any fault that produces a "want" a normal fault, and any fault that causes a duplication of the deposit they consider to be a reverse fault. This is certainly not in accordance with the general practice of geologists, who define a normal fault as one in which the hanging wall side of the fault is at a lower level than the footwall side, quite independent of whether such motion has produced a want or a duplication of the deposit, and some cases are known in which a normal fault as usually understood has produced a duplication, so that such a fault according to the definition by the authors would be called a reverse fault. The chapter on Mining Economics is especially interesting, because it includes sections on Sampling and Valuation. These are subjects on which the views of different engineers are likely to differ somewhat widely, but it may fairly be suggested that if the authors had realised that neither quantity nor grade of ore can ever be known exactly in advance, however well developed the property may be, and that the figures adopted for these are really only the most probable values, each of which is necessarily affected by a probable error, they would hardly have recommended the comparatively crude system of simply taking no account at all of exceptionally high values, such as are occasionally obtained in sampling even the most uniform deposits. It is surely preferable to use a method based on the laws of probability such as the principle described by Mr. David Brunt in his work "The Combination of Observations."

The best chapters in the book are undoubtedly those dealing with actual mining practice, the section on Shaft Stations being a case in point. The first chapter dealing with the history of the Rand contains several inaccuracies. There is, for instance, no evidence at all that the gold found by Carel Kruger in 1834 came from the Witwatersrand. The Pilgrim's Creek deposits were among the first to be worked, and the area usually spoken of as the Lydenberg district soon followed; the De Kaap goldfields followed some years after, and then came the discovery of the Witwatersrand deposits. The authors give no hint of the enormous richness of some portions of the oxidised outcrops of the Banket beds; parcels of these yielded over 100 oz. of free gold to the ton, and in the early days quite a number of diggers did very well by hand-dollying and panning these rich outcrops. Of course, all this is ancient history, about half a century old, and there are probably few men alive to-day who remember these early days, but no historical account is complete without some reference to these facts. As stated in the work by Messrs. Hatch and Chalmers, "The Gold Mines of the Rand," in 1894 the average value of the total rock crushed at the Robinson Mine was between 26 dwt. and 27 dwt., whilst the Ferreira Mine in the same year produced ore averaging nearly 34 dwt. per ton, and the average mill grade in that year for the four richest mines ranged from 20·5 dwt. to nearly 23 dwt. per ton. It need hardly be said that the deep unoxidised banket, which is now practically the only material mined, is of a far lower grade than this.

In the chapter on Geology only a few words are devoted to the acutely debated question of the origin of the gold in the banket; two theories, which are here spoken of as the placer theory and the infiltration theory, are the most widely held. Here it is stated that the former theory is almost always accepted, but it may be noted that this is not the view put forward by Mr. C. B. Horwood in his book "The Gold Deposits of the Rand." It cannot really be said that either one of these theories has as yet gained general acceptance, both having their advocates.

It will be seen from this brief review of a very important work that those portions dealing more especially with mining practice and technology may be accepted without hesitation, but that the authors cannot be held to have been equally successful whenever they have ventured on branches of the subject that are somewhat more remote from the main matter of the book.

The Competitive Position of Coal in the United States. New York: National Industrial Conference Board. 1931. Price 3 dollars.

As its title very clearly shows, the object of this book is an examination of the present position and future prospects of the coal industry of the United States of America. At first sight, it might be thought that such a work is of interest only to the citizens of the United States, but this is really far from being the case. The day has gone by when coal producers in any country can afford to ignore the trend of coal production in other countries, and this statement is especially true of Britain. There was, of course, a time when British coal production ruled the markets of the world, but that time has now gone—probably for ever. We in this country had the benefit of great natural advantages in the character and position of our coalfields, and this fact enabled us to take and maintain the lead in coal production for many centuries. Other countries, however, by dint of hard work, have now developed their coal resources, and are actively and successfully competing with us in the coal markets of the world. It is to be feared that this fact, unpleasant as it may be to our coal producers, has not yet been as fully recognised as it ought to be, and our coal miners in particular do not appear to have awakened to the fact that they are no longer "the only pebble on the beach." Our great natural advantages gave us an easy lead over our rivals, and has no doubt induced in British coal miners the idea that they have some kind of prescriptive right to live better than coal miners in any other part of the world. It is time that they awoke to the fact, unpleasant though it may be, that they cannot live better than others unless they work better, and that they do not do this is only too evident from the book before us. For example, the output of coal per man per day in Great Britain in the year 1929 was 1·0845 (statute) tons. Table G in the present book shows that in that same year in Pennsylvania the output per man per day was 4·73 (short) tons, and in West Virginia 5·34 (short) tons, these two States producing respectively 143·5 and 138·5 millions of tons out of a grand total of 535 millions of (short) tons produced in the whole of the United States, whilst it is precisely in these two States that opencast coal mining plays an exceedingly unimportant part.

The fact that it is impossible to get a true picture of the position of coalmining in any one country without considering its relations to the world as a whole is well recognised in the book before us, the first part of which is taken up by a discussion of the position of the United States in the world coal industry. It can only be said that the position of coal production in other countries has been very carefully studied and is fully recognised here, as may easily be seen by reading the comments upon the British coal trade:—"The prolonged British coal strike of 1926 was a very important factor in giving Polish coal a foothold in Northern European markets." The paragraph in which this sentence occurs points out that although there has been an actual increase in the coal consumption in many of the markets which at one time took all their supplies from Great Britain, British coal has not only failed to recover its former position, but has also had no share in the increased demand. It is recognised that the European international coal trade "has become more highly competitive and seems to offer no adequate opportunity of relieving materially the present depression of the British coal industry." Those who are in touch with the coal industry in this country cannot fail to recognise the accuracy of the view here put forward.

As regards the industry as a whole, this report points out that the principal coal-producing countries of the world are facing difficulties in three main directions, namely, over-capacity of production, growing competition from other sources of energy, and a marked increase in fuel efficiency. The importance of the last item is well shown by a table showing the ratio of fuel consumption to electricity produced. Thus in the year 1919 3·20 lb. of coal were consumed for each kilowatt-hour of electricity produced, and in 1930 the consumption had come down to 1·62 lb. It is proper to remark that here, as elsewhere, in this book, the fuel consumption given includes the coal equivalent of other fuels. Thus, 3·6 barrels of oil products in general or 23,000 cubic feet of natural gas are taken as equivalent to 1 short ton of coal; lignite is reduced to the equivalent of bituminous coal on the basis of 2 to 1; and brown coal on the basis of 4·5 to 1. For present-day purposes 1 kilowatt-hour of electrical energy generated by water power is taken as equivalent to 1·69 lb. of coal. The authors of the book, however, show that savings in the cost of production are possible, especially by the application of mechanisation to the coal industry. They point out that in the United States mechanical coal loading is the latest phase of mechanisation. There, they state, that "although accounting for only 10 per cent. of the coal mined in 1930, it has definitely passed the experimental stage and has proved its practicability." They go on to point out that "mechanical loading of coal involves the necessity for mechanical preparation and cleaning," and that this latter operation improves the quality of the coal, is a definite advantage to the consumer, and is an important factor in reducing the total tonnage of fuel required for any given purpose. It need hardly be said that this statement and the subsequent statement, "mechanised mining is here to stay," are as true of conditions in Great Britain as they are of the United States.

Finally, the book shows what some people are beginning to find themselves compelled to admit in this country, namely, that uneconomic coal mines must disappear, and both countries will be bound to acquiesce in one of the conclusions of the book before us, namely, that "it is futile to try to gloss over the fact that the eventual growth of larger companies must mean the extinction of other companies."

It will be seen from what has been said that this book contains many lessons of great importance to coal producers in general, and not merely to the coal producers of the United States. The difficulties of the industry are to a great extent world-wide. They are necessarily more acute in those countries in which the industry of coal production has been a long-established one; but they point very definitely to the fact that in all coal-producing countries a large measure of reorganisation is imperative in order to meet the changing conditions in the world's markets.

SHORT NOTICES.

Marlborough's German Technical Words and Phrases. Third edition. By E. M. Rollfs. London: E. Marlborough and Co., Ltd., 51, Old Bailey, E.C. 4. Price 7s. 6d. net.—For its third edition this dictionary has been enlarged and many additional terms and phrases have been incorporated. It is intended for use by those having a working knowledge of German and is of the "classified" type. For example, under the word "brick," in heavy type, there are nearly two columns of entries, covering the vocabulary of brick-making. Here one may find, not only such words as brick-grog, brick kiln, and so on, but loam, clay, sand, strike, &c. Even more space is devoted to iron, whilst ships and shipping fill nearly five columns. "Technical" must be interpreted in a wide sense, for here we find several pages devoted to Music and more to Medicine, to mention but two subjects. We observe that many of the translations are not as happy as they might be. The author evidently found it difficult to find the right English interpretations of some German words. Will anyone, for example, recognise "dry-burning" coal, "chain-wales," or "steam-room," and is the gentleman who orders a condenser for his steam plant likely to get what he wants if he asks for a *verdichtungs apparat*? Whilst the dictionary is not without value, use of it should be exercised with discretion.

Let's Help! A Collection of Good Causes. By Sir Charles Bright, F.R.S.E., M. Inst. C.E. London: George Routledge and Sons, Ltd., 68–74, Carter-lane, E.C. 4. Price 4s. 6d.—Engineers, as well as others, probably find themselves at times in need of information about societies and institutions which are at the present time doing philanthropic work amongst all sections of the community. In this book Sir Charles Bright has given helpful details of the constitution, aims, and objects of many such organisations, which to many are known by name only. The book is not intended primarily for technical men, but doubtless such sections as those which refer to the Polytechnic, the National Smoke Abatement Society, the National Institute of Industrial Psychology, the Industrial Welfare Society, and the British Science Guild will prove of value to engineers and industrialists generally.

BOOKS RECEIVED.

Railroad Construction: Theory and Practice. Ninth edition. By W. L. Webb. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 37s. 6d. net.

The Catalytic Partial Oxidation of Ethyl Alcohol. By D. B. Keyes and R. D. Snow. Urbana: Engineering Experiment Station, University of Illinois, U.S.A. Price 20 cents net.

Engineering Materials. Vol. II.: Non-ferrous Metals and Organic Materials. By A. W. Judge. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C. 2. Price 40s. net.

Mitteilungen des Institutes für Strömungsmaschinen der Technischen Hochschule Karlsruhe. By Professor W. Spannhake. Berlin: V.D.I. Verlag, Dorotheenstrasse 40, N.W. 7. Price 4 marks.

Mathematics for Students of Building. Book I. By F. E. Drury, M.I. Struct. E., and W. T. Haslam, B.Sc. London: Edward Arnold and Co., 41–43, Maddox-street, W. 1. Price 4s. 6d. net.

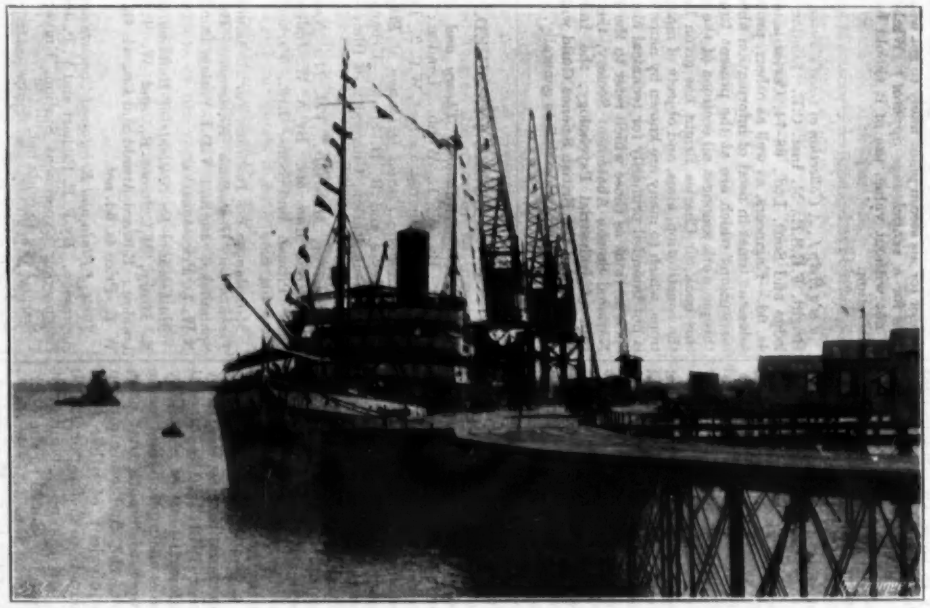
Tests of Plain and Reinforced Concrete made with Haydite Aggregates. By F. E. Richart and V. P. Jensen. Urbana: Engineering Experiment Station, University of Illinois, U.S.A. Price 45 cents net.

Le Pompe Centrifughe: Calcolo e Costruzione. By Ing. G. Zappa, Prof. Ing. F. Giordano and Dott. Ing. G. Mainardi. Milan: Ulrico Hoepli, Editore Libraio della Real Casa, Italy. Price L. 45.

DEEP WATER WHARVES AT BEIRA, PORTUGUESE EAST AFRICA

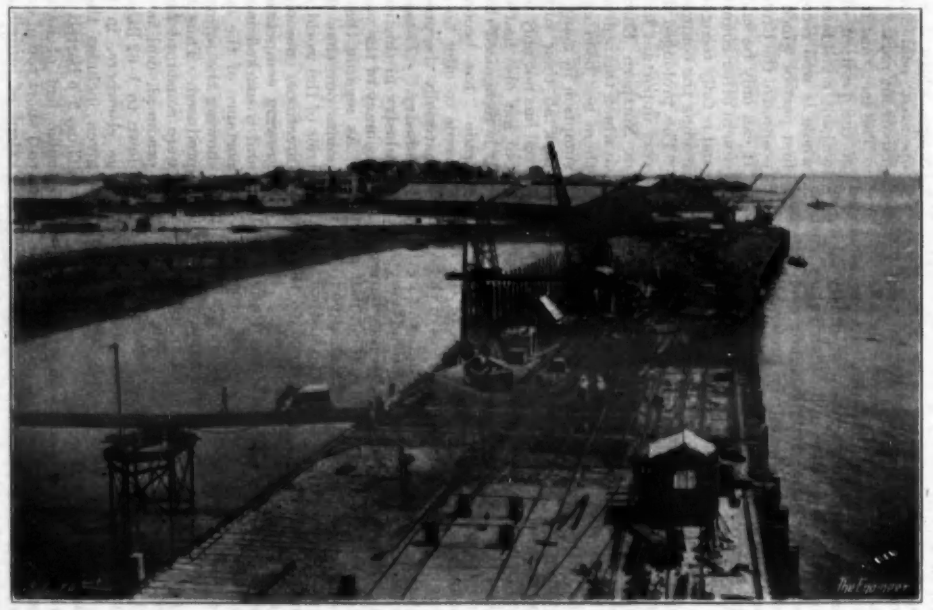
MESSRS. C. S. MEIK AND HALCROW, MM. INST. C.E., WESTMINSTER, CONSULTING ENGINEERS

(For description see opposite page.)

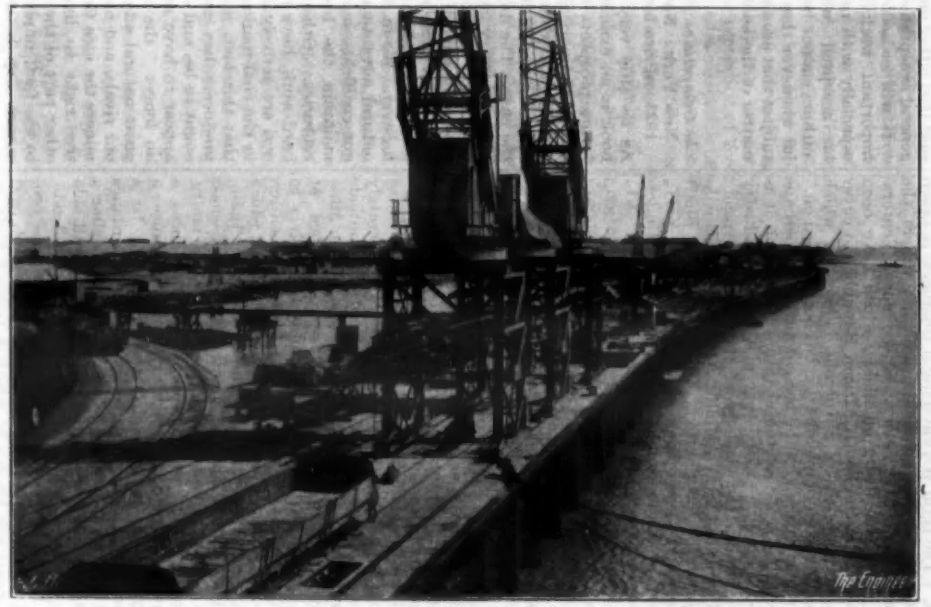


DEEP WATER WHARF NO. 1 COMPLETED

WHARVES NOS. 2 AND 3 UNDER CONSTRUCTION



DOWNSTREAM VIEW OF WHARVES NOS. 1, 2 AND 3



JUNCTION OF NO. 2 WITH NO. 1 WHARF

Port Improvements at Beira.

THE Port of Beira in Portuguese East Africa, 20 deg. south of the Equator, forms a natural outlet for a considerable portion of that territory, and can also claim to serve in a similar capacity Nyasaland and Southern and Northern Rhodesia. It is situated at the mouth of the Pungue, a river flowing south into Sofala Bay. The growth of its trade has been noteworthy in recent years. In 1914, 501 vessels of a gross tonnage of 1,460,783, used the port, the cargo handled being 185,675 tons. In 1923 the number of vessels was less, namely, 474, but their aggregate gross tonnage was greater at 1,872,312, while the cargo handled increased to 524,080 tons. During 1929, 668 ships of a gross tonnage of 2,899,430 visited the port, and the cargo handled was 1,062,007 tons.

Until 1929 the whole trade of the port was dealt with by lighters. The vessels lay at anchor in the river, while the lighters serving them loaded and unloaded their cargoes at wharves in the Chiveve Creek, an offshoot from the river. This method of dealing with the imports and exports was responsible for much delay, because, as a result of the restricted depth of water at the lighter wharves and the large range of the tide—21ft. at springs—the barges grounded at a little under half tide.

In 1927 an English company—Beira Works, Ltd.—by agreement with the Portuguese Mozambique Company and the Companhia do Porto da Beira, began extensive improvements at the port. This company began by purchasing from the Beira Junction Railway Company the existing lighter wharves, sheds, and cargo-handling equipment. In order to secure a quick increase in the facilities of the port, it built an extension to the lighter wharves. This extension was brought into service in the early part of 1928. Simultaneously, the company began the construction of the first of a number of deep-water berths on the left bank of the Pungue River. This berth, the position of which is shown on the accompanying plan, was finished and brought into use in 1929. Following these improvements the average length of stay of vessels in the port was reduced from 12 days 16 hours in 1927 to 5 days 5 hours in 1930.

In addition to the work above mentioned, the company dredged the river for the purpose of enlarging and deepening the area available for the anchorage of ships. The bottom of the river did not provide a good holding ground, and ships had frequently dragged their anchors during storms. To meet this contingency, eight fixed moorings were laid for the use of ships up to 12,000 tons. Before 1929 almost all the cranes and the other machinery at the port had been operated by steam power. While the first deep-water berth was being built, an electric power station was erected on the adjacent land. From this station power is now obtained for working the cranes and capstans on the wharf.

The bed and banks of the Pungue River are composed largely of silt and mud with sand in occasional layers. They therefore provide bad foundations for heavy wharves. For the extension of the existing lighter wharves by 360ft., and for the construction of the first deep-water wharf, which has a length of 520ft., screw piles were employed. These piles, of solid steel, are 6in., 7in., or 8in. in diameter, according to their position in the wharf, and are fitted with cast steel screws varying in diameter from 4ft. 6in. to 5ft. 6in. The bracing is composed of tie-rods and turnbuckles, with struts of rolled steel joists and channels. At low water of spring tides, the depth of water at the deep-water wharf is 27ft., but the structure has been designed to permit this depth to be increased to 33ft. when required. The rise of the spring tide being 21ft. and the deck being 5ft. above H.W.S.T., there is at present a total of 53ft. from the deck to the bottom of the river, with provision for an increase of this distance to 59ft.

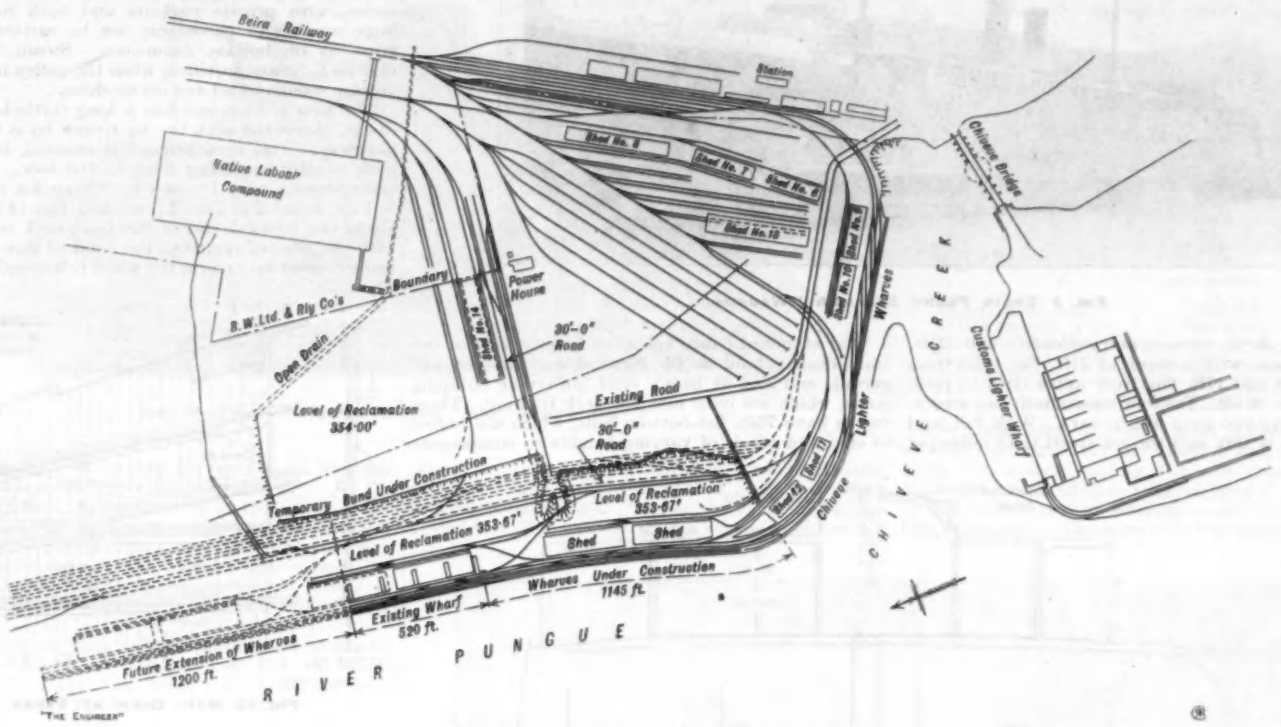
Early in 1930 the work of constructing two additional deep-water berths was begun. These wharves, as the plan shows, join the downstream end of the first deep-water wharf to the outer end of the extended lighter wharves in the Chiveve Creek. For these two additional wharves a new type of construction was adopted. Instead of the piles previously used, cast iron screwed cylinders, with an outside diameter of 3ft. and a screw 7ft. in diameter were employed. These cylinders are screwed, on the average, 30ft. into the ground, and reach to a level 5ft. above L.W.S.T. The longest of them measures 67ft. Upon them there is carried a superstructure composed of heavy-section joists and channels, with a steel trough and concrete deck The wharves are provided with three lines of 3ft. 6in. South African standard gauge tracks, of which that nearest the edge of the wharf is spanned by electrically driven portal cranes.

In rear of the new wharves, eight rows of reinforced concrete and timber piles are being driven, on which transit sheds are to be erected. The area behind the wharves is to be reclaimed by pumping on shore the material dredged from the river.

The consulting engineers for the work which we have described are Messrs. C. S. Meik and Halcrow, of Westminster. The principal contractors are Pauling and Co., Ltd., Westminster, with Braithwaite and Co. (Engineers), Ltd., as sub-contractors for the steel work. The three berths are equipped with twelve Stothert and Pitt electric cranes, nine of which have a capacity of 3 tons at a maximum radius of 55ft., and three a capacity of 6 tons at 42ft. The electric generating station contains two vertical oil engines by Mirrlees, Bickerton and Day, Ltd., each coupled to a direct-current generator of 220 kW at 500 volts. Fluctuating loads are dealt with by means of a storage battery of the lead plate type, having a capacity of 900 ampère-hours when discharged in ten hours. The power is transmitted on the three-wire system, and the station is equipped with an electric balancer and a switchboard. The electric equipment was supplied by the British Thomson-Houston Company, Ltd.

The dredging plant comprises a non-propelling, belt-driven bucket ladder dredger, which is capable of dredging to a depth of 60ft. The buckets have a capacity of 35 cubic feet, and the maximum output is 800 cubic yards per hour. The material dredged from the river is discharged into three hopper barges of 400 cubic yards capacity, which are handled by a single-screw tug boat. In addition, there are provided a self-propelling hopper barge of 300 yards capacity and a 7-ton floating Priestman grab crane. The reclamation plant consists of a floating pumping station, which can pump 150 cubic yards of solid material per hour to a maximum distance of 3000ft. The discharge pipes, 14in. in diameter, work in conjunction with twin pumps driven by high-speed steam engines supplied with steam by two Scotch boilers. The hull of the vessel containing the reclamation plant is 94ft. 3in. long between perpendiculars, and has a moulded breadth of 26ft., and a moulded depth of 6ft. 6in. The vessel and its equipment were supplied by Fleming and Ferguson, Ltd., of Paisley.

The first view reproduced on page 428 illustrates deep-water wharf No. 1 in the completed state. In the foreground to the right is to be seen the curved approach viaduct, whereby access is obtained to this wharf from the shore. The second view shows work in progress on the second and third deep-water wharves. The concrete piles to carry the sheds in rear of the wharves are being driven, while in the background the completed first wharf and its approach viaduct are to be seen. In the third engraving a view of the two later wharves, looking downstream, is reproduced. Troughing, plate-laying, and concreting on the deck are in progress. The fourth view shows the extensions, as seen from their point of junction with the first deep-water wharf.



PLAN OF PORT WORKS AT BEIRA

American Sea-Going Train-Ferry Steamers.

By E. E. R. TRATMAN.

No. II.*

FOLLOWING the general review of the Lake Michigan train-ferry service, which was given in the first article, it will be appropriate to describe more particularly some of the individual lines and their steamers. In this connection it is to be noted that several new boats have been introduced during the past few years, which is an indication of the importance and growth of the traffic.

ANN ARBOR LINE.

The Ann Arbor Railroad, with the city of Ann Arbor as an important point, is a 300-mile line extending from Toledo, where numerous railways centre, north-west to Frankfort, a small town on the Lake Michigan coast, which is served only by this line. It is of interest as being the first line to operate a train ferry across the Lake, having put two wooden steamers in service in 1892. Each boat had a carrying capacity for twenty-four freight cars, which at that time were of somewhat smaller average capacity than those of the present day. The boats were 267ft. long, 52ft. beam, with 12ft. loaded draught, and a displacement of 2550 tons. Besides the twin screws at the stern, there was a third screw at the bow, the stem sloping sharply back to the keel from a point just below the water line. This screw, intended to dislodge and break up the ice, was of very heavy design. It was not used on later boats, as already explained. Each of the three screws was driven by a compound engine having cylinders 20in. and 40in. in diameter and 36in. stroke.

Steel steamers were added to this line in 1898, 1906, 1910, and again in 1917. In 1923 the first of the steel boats, the "Ann Arbor No. 3," was lengthened 48ft., making it 307ft. long. At the same time the old compound engines were replaced by triple-expansion engines, with jet condensers and a forced draught system for the boilers. This railway

* No. I. appeared April 8th.

has now in service seven car ferry steamers, which during 1928 made 4300 trips across the lake and carried nearly 100,000 freight cars.

One of the largest train-ferry steamers of this type is the "Wabash," which was put in service by the Ann Arbor Railroad in 1927. This vessel is 380ft. long overall, 368ft. between perpendiculars, and 57½ft. moulded beam, with a depth of 21ft. 6in. from train deck to keel and 17ft. 6in. from upper deck to train deck, or 39ft. in all. The four lines of rails can accommodate thirty-two long freight cars. With full load the draught is 16ft. and the sea speed is 14 miles per hour. This steamer was illustrated in Fig. 1, and the design of its ice breaker bow in Fig. 5. Another view, with the steamer moored at its Frankfort landing, is shown herewith in Fig. 9. A cross section of the main portion of the hull is given in Fig. 10, which, with the plan of train deck and deck framing, Fig. 11, shows the structural design. These drawings are, in general, representative or typical of the construction of the train-ferry steamers on the Lake.

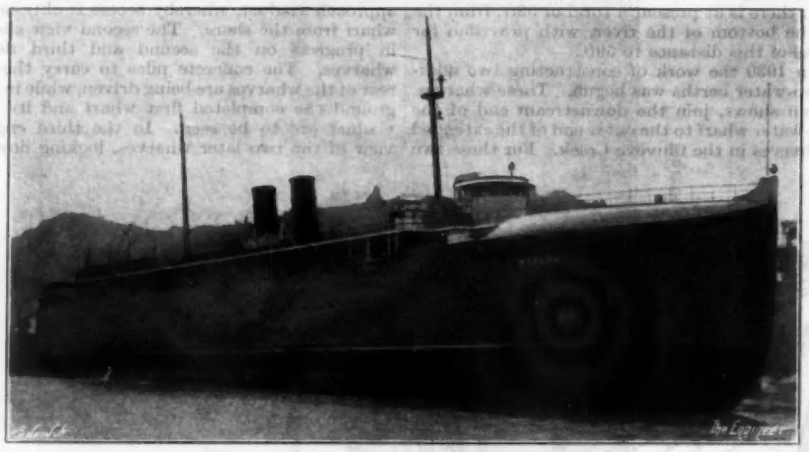


Fig. 9—Train Ferry Steamer "Wabash."

Transverse bulkheads divide the hull into eight water-tight compartments beneath the main deck. There is no double bottom, but wing tanks holding 60 tons of water each are provided for trimming the ship to an even keel if the car loads are unevenly distributed. These tanks are served by the ballast pumps. The holds also contain two fresh water tanks of 3000 gallons each, and a sewage tank of 2000 gallons to receive the discharge from all plumbing below the water line. The coal bunkers are arranged on either side of the boiler-room.

Four standard gauge tracks or lines of rail on the train deck extend as far forward as clearance will permit, and end at heavy steel buffers or bumping posts, which are built into the deck framing. These tracks have 75lb. flat-bottom rails, which are bolted to chairs or stools of varying heights to compensate for the transverse camber of the deck. These chairs are steel plates bent to the form of saddles or inverted troughs and are riveted through the plating to the deck beams. They are about 4in. long, or 8in. at the rail joints. Outside each track rail and riveted to the deck is a 75 lb. clamping rail, serving as a footing for the inclined screw jacks, which are run up to engage with the sills or sole plates of the cars in order to steady them against any rolling or swaying on the bogie springs brought about by the movement of the steamer in a seaway.

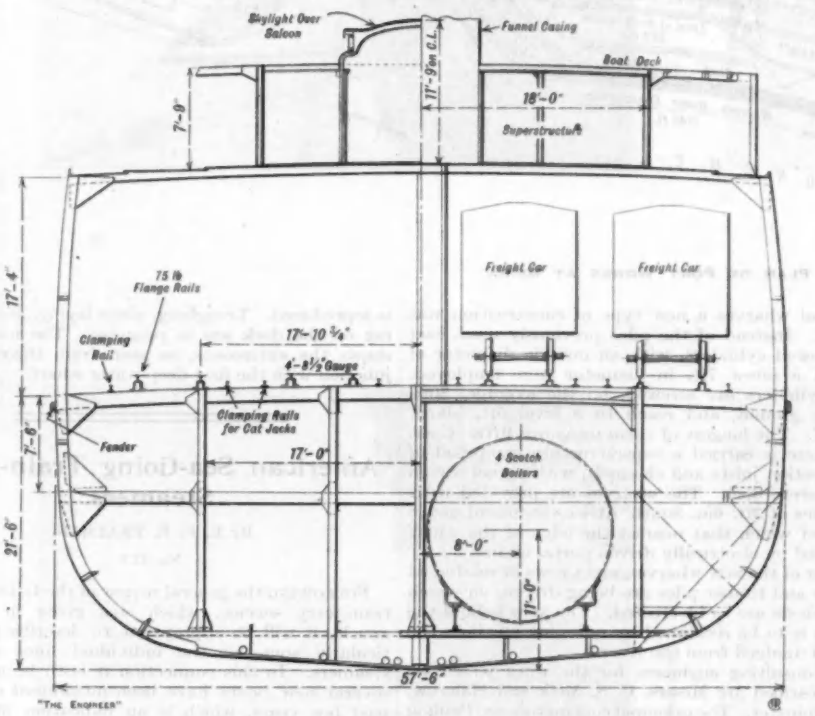


Fig. 10—Cross Section of Hull of S.S. "Wabash"

At the stern, however, the steel deck is covered with oak planking, 4in. thick, bolted to the plating and well caulked. Upon this are lines of ½in. and ⅝in. steel plates to carry the rails, as illustrated in Fig. 12. This construction makes a convenient decking for motor vehicles in running on and off the boat, although they have to climb over some of the rails unless filler planks are laid between the rails. It will be seen from Fig. 12 that on the fantail of the stern deck the four tracks begin to converge to meet the two tracks of the landing apron and the approach.

Upon the upper deck is a superstructure about 35ft. wide and 8ft. high, the roof beams of which are extended to the full hull width and supported by stanchions at the sides in order to carry a boat deck, as shown in Fig. 10. In this deck house or superstructure are the saloon, state rooms, ladies' room, smoking room, dining room, galley, and crews' quarters. State rooms provide accommodation for about forty passengers, and some of the cabins are suites, with private parlours and bath rooms. A large number of passengers can be carried on day trips, as on holiday excursions. Steam heat and electric light are provided, while the galley has a cold storage room and a 1-ton ice machine.

The bow is high and has a long turtle-back forecastle, connected with the boat deck by a bridge or gangway. This arrangement is unusual, the upper deck usually extending flush to the bow. The two arrangements may be seen by comparing the views in Figs. 1 and 2 in Part I.; see also Fig. 13 herewith. Upon the forward end of the boat deck is a house with the officers' quarters, the front of this structure being carried up to form the wheel house and navigating bridge. At the after end of the upper deck is a second wheel house, which is used by the deck officer when manœuvring and backing the ship to its landing. The train deck is open at the stern, but during the voyage a hinged bulkhead or stern gate, 5ft. high, is lowered to seat on the deck. This gate is attached to pivoted arms, and is raised by a power winch, so as to span the deck like an arch, and to permit the cars to pass under it. A powerful electric winch to handle the swinging cable of the ship when turning is mounted in the deck space between the forecastle and superstructure.

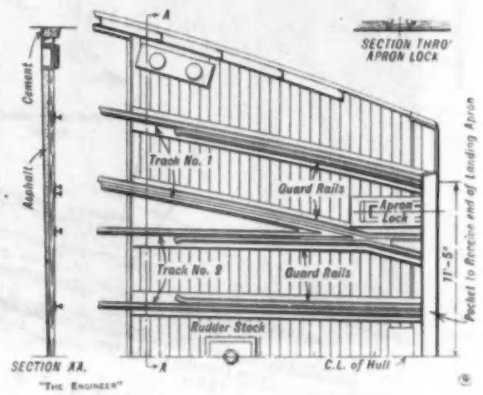


Fig. 12—Rail Deck at Stern

In the engine room are the two triple-expansion engines, having cylinders 20½in., 34in., and 56in. diameter, by 36in. stroke, each equipped with a turning or barring engine 6in. by 6in., and a reversing engine 10in. by 18in. Jet condensers have 6in. turbine-driven pumps for handling the condensate. The propellers are four-bladed screws 12ft. in diameter, 14ft. 6in. pitch, which revolve outboard. Four Scotch boilers, with three furnaces each, give a total heating surface of 2750 square feet, and carry 185 lb. pressure. They are single-ended boilers, and are mounted in pairs, with the firing-room between them. Each pair has its own uptake and funnel. An ash ejector of the hydraulic jet type is fitted on each side of the fire-room, but the outlets are so far above the water line that the after part of the side of the hull is smeared with wet ashes. Hot air forced draught on the Howden system is supplied by two engine-driven fans, 66in. in diameter.

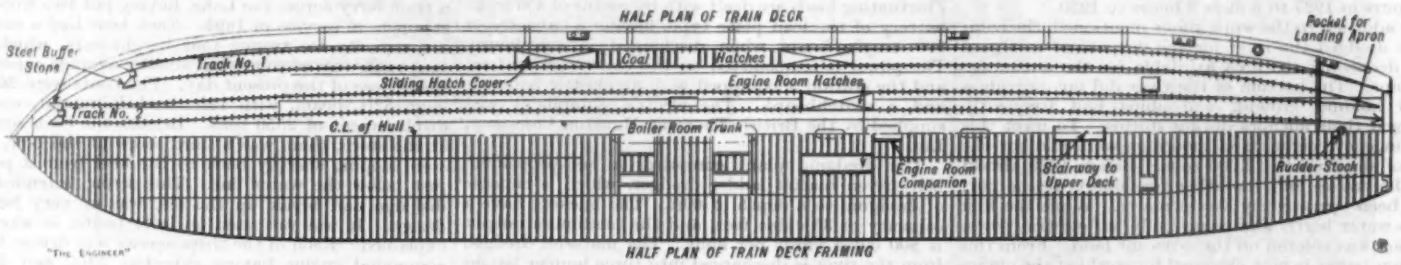


Fig. 11—Plan of S.S. "Wabash" at Train Deck Level

The "Wabash" is the flagship of the fleet. The other boats are 307ft. to 360ft. long, of 2700 to 3000 gross tonnage, and each with engines of about 3000 H.P. Of these other boats, the largest is the "Ann Arbor No. 7," illustrated in Fig. 13, which was built in 1925. She is 360ft. long and has a 56ft. beam, with a depth of 21ft. 6in. below the train deck. There is a clear headroom of 16ft. above the rails of

this deck, and the loaded draught is 16ft. The vessel has a loaded displacement of 6510 tons; gross tonnage, 2954; the net tonnage being 1426; and the cargo capacity 2240 tons. The two triple-expansion engines, of 1500 H.P. each, have cylinders 20½in., 34in. and 56in. in diameter, with 36in. stroke. Steam of 185 lb.

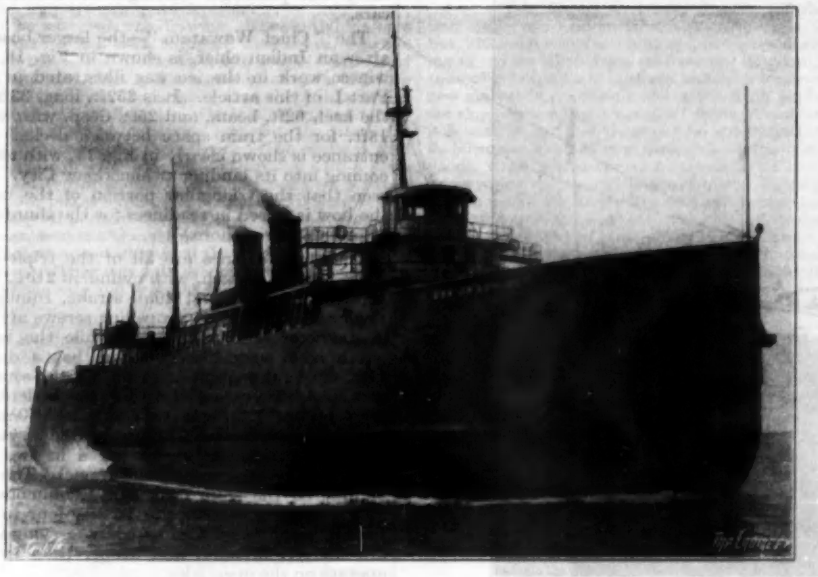


FIG. 13—TRAIN FERRY STEAMER "ANN ARBOR NO. 7"

pressure is supplied by four Scotch boilers, and the bunkers have capacity for 400 tons of coal.

The propellers have a diameter of 12ft. with a 15ft. pitch. With a full load of 28 freight cars the sea speed is 15 miles per hour. Deck passengers, to the number of 300, may be carried, while fourteen state rooms have berths for twenty-eight passengers. The vessel is manned by a crew of thirty-six men under eight officers.

Ice conditions such as these train ferry steamers have to encounter are illustrated by Fig. 14, which shows some of the Ann Arbor Line boats working through solid and broken ice at Frankfort.

PERE MARQUETTE LINE.

As noted already, the Pere Marquette Railroad was the second to extend its system by train ferry steamers across Lake Michigan. It has now seven boats in service and during 1928 they carried 95,300 cars. One of its old boats was built with an ice-breaking screw at the bow, but in operation the screw was found to be a detriment rather than an advantage, and it is reported that, after its removal, the boat proved more satisfactory. All the present boats have twin screws, and all but two have triple-expansion engines and Scotch boilers. The exceptions have turbo-electric equipment and water-tube boilers.

These two boats, the "City of Flint" and "City of Saginaw," which were put in service in 1930, represent a radical development on account both of their power equipment and of their speed of 18 miles an hour, as compared with 12 to 14 miles an hour for the other boats. The "City of Flint" on her trial trip was shown in Fig. 2 of Part I.

Each steamer has two independent units for the two screws, and the electric equipment is designed with a view to efficient and reliable service under the peculiarly severe conditions incident to driving the vessels through heavy ice in winter. Each unit comprises a turbo-generator set and a motor coupled directly to the screw shaft. The A.C. generators are of the 2300-volt, three-phase, 60-cycle type and—with the turbine—they run at 3600 revolutions per minute; but governors reduce this speed to 2700 revolutions when the ship is manœuvring. The A.C. slip-ring motors are of 3600 H.P. each, with a normal speed of 120 revolutions. Each motor is ventilated and cooled by a fan with 25 H.P. motor. The propeller speed is varied by means of a resistance connected in series with the rotors, and also to some extent by varying the turbine speed. Electric auxiliaries take current from the main generators through transformers. The engine-room looks like a power-house or central station rather than a ship's engine-room. The motors are in an adjoining compartment.

FIG. 14—TRAIN FERRIES AMIDST ICE

Steam is supplied by four Babcock and Wilcox water-tube boilers with horizontal tubes. They have a total of 20,000 square feet of evaporative surface and 1200 square feet of superheating surface, and deliver steam at a temperature of 620 deg. Fah. and at 315 lb. pressure. Mechanical stokers and chain grates do the firing, so that the stokehold is clean and quiet, with no fires to be seen, except through peep-holes. Thus, conditions are radically different from those of the boiler rooms on the hand-fired boats.

Coal from the bunkers is fed, automatically, to an inclined chain conveyor which carries it up to a crusher to be reduced to the proper and uniform size for the grates. From the crusher it is carried to overhead hoppers or bins having tubular spouts, through which it is fed to the stoker magazines. Instead of the usual pair of funnels, all the boilers are served by one large funnel of oval section. While the state-room accommodation is limited to about fifty passengers, each of these vessels is authorised to carry 500 deck passengers on day excursion trips.

The latest and largest of the steamers of this line having triple-expansion engines is the "Pere Marquette No. 21," which is illustrated in Fig. 15, entering the harbour at Ludington. This view shows the stern opening partly closed by the hinged bulwark or stern gate. A comparison of this boat with one of the new turbo-electric steamers is given in the following table:—

Train-ferry Steamers: Pere Marquette Railroad.

	"No. 21," triple-expansion.	"City of Flint," turbo-electric.
Length over all	360ft.	380ft.
Beam, moulded	56ft.	56ft.
Depth, below train deck	21½ft.	22½ft.
Draught, loaded	16ft.	17ft.
Displacement, tons	6000	7000
Gross tonnage	2992	—
Net tonnage	1511	—
Cargo capacity, tons	2600	2800
Engines, twin-screw	triple-expansion	turbo-gen. with shaft motors
Engines, H.P., each	1350 H.P.	3600 H.P.
Bunker capacity	350 tons	600 tons
Speed, loaded, miles per hour	14	18
Number of cars carried	26	30
Officers and crew	46	42

GRAND TRUNK LINE.

The train ferry between Grand Haven and Milwaukee was started by the Grand Trunk Railway in 1906, but a new landing has now been built at Muskegon, north of Grand Haven, and it is intended to run boats between Milwaukee and both of these east coast ports. There are now four boats in service,

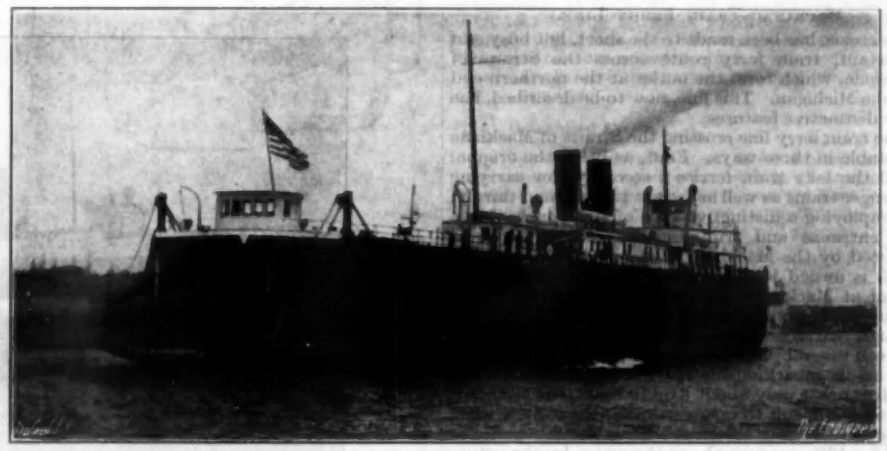


FIG. 15—TRAIN FERRY STEAMER "PERE MARQUETTE NO. 21"

two of which—the "Madison" and "Grand Rapids"—were built in 1927. During the winter of 1929 one of the older boats—the "Milwaukee"—was lost with all hands during a violent storm. A new boat was then ordered in 1930 and put in service early in 1931. This latest addition is the "City of Milwaukee," the flagship of the fleet, Fig. 16.

All these new boats are of the same general type already described and are practically identical in design and dimensions. Taking the "Milwaukee" as an example, she is 360ft. long, 348ft. between perpendiculars, 56ft. beam, and 21ft. 6in. deep, with a draught of 10ft. 3in. light and 16ft. loaded. Between decks the clear height of the train deck is 18ft. 3in. The hull has frames made of 10in. rolled steel channels spaced 24in. between centres and is divided into seven water-tight compartments, with a heavily reinforced ice-breaker bow. The vessel is of 2945 gross and 1490 net tonnage, with a cargo or deadweight load capacity of 2600 tons.

On the main deck are four lines of rails with capacity for thirty freight cars 42ft. long overall. In the superstructure on the upper deck are a saloon and large observation room at the forward end and state rooms along each side, with accommodation for forty passengers. It has also well-equipped smoking room, ladies' room and toilet rooms. Aft of the saloon are the purser's and steward's offices, dining room, galley, storerooms and crew's quarters. At the after end of this deck is a wheel house, from which the ship is handled when turning and backing into the landings. This wheel house and the hinged stern gate, already described, were shown in Fig. 7 of Part I. The captain's room and officers' quarters are in a house above the forward end of the superstructure and surmounted by the wheel house with its navigating bridge.

Triple-expansion twin-screw engines of 1500 H.P.

each, having cylinders 20½in., 34in., and 56in. diameter, with a stroke of 36in., give a sea speed of 14 miles an hour. Four Scotch marine boilers carrying 185 lb. pressure are arranged in pairs on opposite sides of athwartship firing room or stokehold, each pair or

Fig. 16—Train Ferry Steamer "City of Milwaukee"

battery having its own uptake and funnel. These boilers are 14ft. 6in. in diameter and 12ft. long. The officers and crew number together about fifty and there is cabin accommodation for twenty-four passengers.

Mackinac Train Ferry Line.

Reference has been made to the short, but busy and important, train ferry route across the Straits of Mackinac, which form the outlet at the northern end of Lake Michigan. This line, now to be described, has some distinctive features.

The train ferry line crossing the Straits of Mackinac is notable in three ways. First, as being the original of all the lake train ferries; secondly, for carrying passenger trains as well as freight trains; and thirdly, for employing a distinctive type of steamer, having a bow entrance and triple screws. This service is operated by the Mackinac Transportation Company, which is owned jointly by the three railways terminating at Mackinaw City, on the south side of the Straits, and at Saint Ignace, on the north side. With through carriages and through trains passengers between several places avoid the trouble of change of cars or disembarking for the water crossing. While the distance is only about 8 or 10 miles, the service is especially difficult to operate during the winter, when the ice is not only thick and solid, but is sometimes piled up 12ft. or more above the water by the action of winds and waves. One of the Straits train ferry steamers in the ice was illustrated in Fig. 3 of Part I. of this article.

The first train ferry steamer on this route was the "Saint Ignace," which was put into service in 1888 and had a capacity for six passenger cars or eight freight cars. She was followed in 1890 by the "Sainte Marie," 316ft. long and 62ft. beam, which was conspicuous by reason of having four funnels, arranged

Fig. 17—Open Bow of "Chief Wawatam"

in two thwartship pairs. These two boats were of timber construction. The "Saint Ignace" was sold in 1913 and was afterwards burned, while the original "Sainte Marie" was replaced a few years later by a larger steel boat of the same name. At present there are two boats in service; the second "Sainte Marie" and the larger and more powerful "Chief Wawatam," shown in Figs. 17 and 18.

Both boats differ from those used on the open lake, in that the trains enter and leave at the bow, while the stern is permanently closed above the train deck. The purpose of this arrangement is to avoid the difficulty of backing steamers into a landing slip filled with ice, but it would not be permissible in the train ferry steamers which cross the open lake and have to encounter heavy seas. During the voyage the bow entrance is partly closed by a pivoted gate or bulwark about 5ft. high, to exclude waves, spray, and ice.

In each boat a bow screw is provided to assist in breaking up and dislodging ice, either at the landing or in the straits. This screw causes a downward current of water, disturbing the support of the ice, which is thus more readily broken down and thrust aside by the ice-breaking bow.

The present "Sainte Marie" is 266ft. long, 232ft. on the keel, with 62ft. moulded beam, and a depth of 25ft. below the main deck, while the height from main deck to upper deck is 18ft. The compound condensing engines for the twin screws have cylinders 32in. by 48in. and 56in. by 48in., while a similar engine for the bow screw has cylinders 28in. by 40in. and 52in. by 40in. Steam at 125 lb. pressure is supplied by six return-tube boilers, each 12ft. 6in. in diameter and 11ft. long, with two 43in. furnaces. This boat can carry ten passenger carriages or fourteen freight cars.

The "Chief Wawatam"—the larger boat—named after an Indian chief, is shown in Fig. 18, while its winter work in the ice was illustrated in Fig. 3 of Part I. of this article. It is 352ft. long, 332ft. 6in. on the keel, 62ft. beam, and 25ft. deep, with a height of 18ft. for the train space between decks. The bow entrance is shown clearly in Fig. 17, with the steamer coming into its landing at Mackinaw City. It will be seen that the triangular portion of the bulwark at the bow is raised in readiness for the shunting engine to pull the cars ashore.

The three engines are all of the triple-expansion type, 2500 H.P. each, with cylinders 21in., 33in., and 52in. in diameter and 40in. stroke, running at 100 revolutions. The two propelling screws are 12ft. 6in. in diameter and 14ft. pitch, while the bow screw, which is of very heavy design, has a diameter of 11ft. 6in. and a pitch of 16ft. All the screws are of cast steel. There are six return-tube boilers, 13ft. 6in. diameter and 12ft. long, each with two 50in. Morrison suspension furnaces. They carry 185 lb. steam pressure. These boilers are arranged in two batteries, each with a main uptake and funnel. The four lines of rails on the train deck can accommodate fifteen long passenger carriages or twenty-four freight cars. It may be noted that these boats ferrying the Straits are shorter, broader, and deeper than those which operate on the open lake.

With regard to the names of the train ferry steamers, it is curious that, until very recent years, it was the custom for each railway to give its boats numbers instead of names, such as the "Pere Marquette No. 21" and the "Ann Arbor No. 7." However, in 1928 the Ann Harbor Railroad put on a new boat which it named the "Wabash." Other railways now name their newer boats from cities served by their

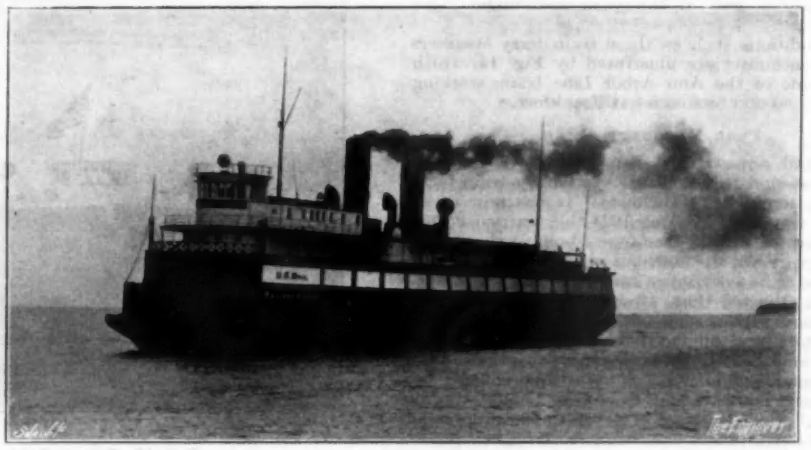


Fig. 18—Train Ferry Steamer "Chief Wawatam"

lines, this practice being a good means of advertising for publicity and popularity.

As to the funnel markings, in which there is some marine interest, all the boats have black funnels, but on some there are distinguishing marks. Thus the "Wabash," which was built for the Wabash Railroad—of which the Ann Arbor Railroad is a subsidiary—has a red band on each funnel. All the other boats of the Ann Harbor Line have a deep white band with a large red "A." The Mackinac boats have a deep white band on each funnel, while the Pere Marquette boats have a red disc, and the Grand Trunk boats have plain black funnels. As an interesting detail, the red "A" and red disc are not simply painted on the funnel, but are cut out of steel plate and riveted in place.

(To be continued.)

A Roller-bearing Axle-box.

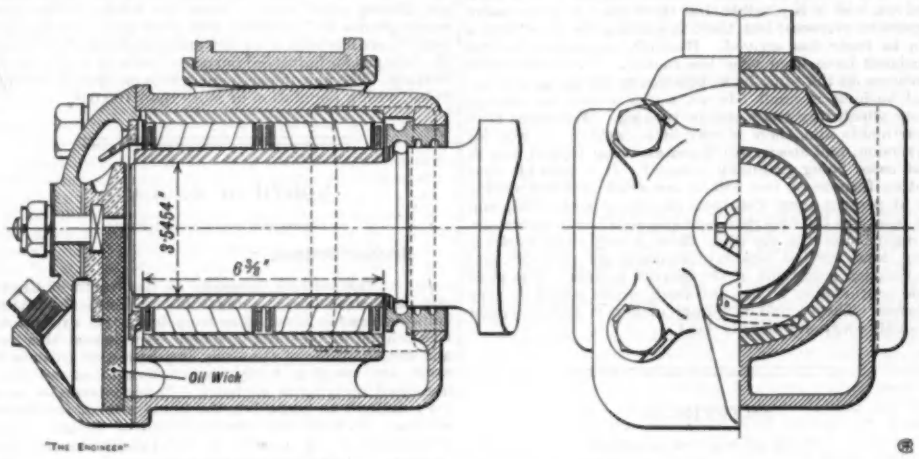
Although it is generally admitted that for moderate and high speeds there is little to choose between ordinary journal bearings and ball or roller bearings for railway work, there is no doubt that in some circumstances, such as the starting from a standstill of heavy trains, the latter are preferable, and it is noteworthy that in America, where very heavy trains are the vogue, serious attention is being given to anti-friction bearings. In the circumstances the bearing, illustrated by the accompanying drawing, which is by Delco-Remy and Hyatt, Ltd., of 111, Grosvenor-road, London, S.W. 1, is of topical interest.

It will be seen that it is of the roller type and is a development of the Hyatt bearing of some twenty years ago. The peculiarity of this bearing is, of course, the formation of the rollers, which are made of a strip of steel wound into a

tight helix and ground to size. The object is to provide a roller sufficiently flexible and resilient to take up the load of impacts and to distribute the radial load evenly over the bearing surface. It may be remembered that in the early days of this type of bearing trouble was experienced through the rollers breaking up and wrecking the remainder, but since then great advances have been made, not only in the design of the bearing itself, but also in the metallurgy of the steel used for the rollers, so that, made of alloy steel, they are now quite dependable.

As will be seen from the drawing, the essential features of the Hyatt bearing are a hardened steel sleeve, which is pressed on to the end of the axle, two sets of rollers held between retaining rings and a hardened steel bush in the axle-box. It will also be noticed that the rollers are of comparatively small diameter, which is accounted for by the fact that they are relatively long and the loading is evenly distributed along their length. The result is that the axle-box is little, if any, larger than one with a plain journal, and it can generally be accommodated between existing horn plates without alteration. It is noteworthy that the several parts of the bearing do not need very fine adjustment, so that the inner race can be fixed on the axle at the place of manufacture and the box assembled at the wagon shops. Then it is only necessary to slip the box on the end of the axle and drop the bogie on the top to complete the job.

These parallel rollers cannot, of course, take up any end thrust, so a substantial bronze pad is fixed on the axle-box cover to bear against the end of the axle. This pad can be adjusted, by means of shims, to give any desired degree of float to the axle, and is lubricated by means of a wick reaching up to the centre and by dippers on one of the retaining rings, which lift oil up from the well below and drip it on to the top of the pad. It is claimed that



SECTIONS THROUGH ROLLER BEARING AXLE BOX

this pad provides considerably greater area to take up end thrust than is possible with the ordinary journal. The oil well in the bottom of the box is of such a capacity that it only needs replenishment after from 10,000 to 15,000 miles of running, and the bearing will work well with any ordinary mineral oil of good quality.

The makers are rather emphatic about the means which should be adopted to prevent oil leaking out of the box where the axle emerges on the inside. They do not approve of felt washers, as they may cause grooving of the axle, but rely on a small clearance and the provision of two grooves, plainly shown in the drawing, which are packed with grease. It is a practice with which we fully agree, for experience has shown that the best protection for a bearing, against both the loss of lubricant and the ingress of dirt, is to allow a collar of grease to collect at the opening and never to disturb it except when absolutely necessary.

In these bearings the pad which transmits the load from the springs to the top of the axle-box is slightly rounded transversely, so that there is no liability for the weight to be concentrated on either end of the bearing, and lugs are, of course, provided on the sides of the box to transmit side thrusts to the horn plates.

In the case of bogies with frames of the diamond or arch-bar type the arrangement for taking up end thrust is modified and a groove is cut in the end of the axle, into which a horseshoe thrust plate is dropped.

LAUNCHES AND TRIAL TRIPS.

ROYAL IRIS II., passenger ferry; built by Harland and Wolff, Ltd., to the order of County Borough of Wallasey; dimensions, 158ft. by 48ft. by 13ft. 1½in. Engines, triple-expansion; pressure, 200 lb. per square inch; constructed by the builders; launch, March 22nd.

DONBY, steamer; built by Wm. Gray and Co., Ltd., to the order of Sir R. Ropner and Co., Ltd.; dimensions, 434ft. 3in. by 55ft. 5in. by 31ft.; to carry cargo. Engines, triple-expansion, 26in., 43½in., 73in. by 48in. stroke, pressure 200 lb. per square inch; constructed by the builders; trial trip, April 1st.

BELLE ISLE, steamship; built by Swan, Hunter and Wigham Richardson and Co., Ltd., to the order of Newfoundland Canada Steamships, Ltd.; dimensions, 245ft. by 37½ft. by 21ft.; to carry passengers and cargo. Engines, triple-expansion; constructed by the builders; launch, April 4th.

ERIN, steamship; built by Workman Clark (1928), Ltd., to the order of Erin Steamship Company, Ltd.; to carry passengers and fruit. Engines, triple-expansion; constructed by the builders; launch, April 5th.

THE INSTITUTE OF METALS.—The twenty-second annual May Lecture of the Institute of Metals will be delivered by Professor Dr. F. Körber, Director, Kaiser Wilhelm-Institut für Eisenforschung, Düsseldorf, on Wednesday, May 11th, at 8 p.m., at the Institution of Mechanical Engineers, Storey's-gate, Westminster, London, S.W. 1, the subject of the lecture being "The Plastic Deformation of Metals."

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Spring Quarterly Meeting.

THE Spring Quarterly Meeting of the Midland iron trade was held in Birmingham to-day—Thursday—but, although there was a large and representative gathering of industrialists from all over the kingdom, up to the time of printing little business had been transacted and no new market development had made itself evident. Tariff developments formed the chief topic of conversation, for it is anticipated that there will be a definite improvement in business, alike in raw materials and in manufactured goods, when producers and consumers of iron and steel know where they are with regard to the duties on imports. It is hoped that during the second quarter business will develop much more rapidly than it did during the first three months of the year. Although the heavy industries in the Midlands generally continue dull, there has, of recent weeks, been a certain improvement in some of the engineering and many of the light metal working industries in this area, and to this and to the tariff anticipations is credited the better tone which characterised most sections of the quarterly gathering in Birmingham to-day. True, the increase in activity in the finishing trades has not been sufficient up to now to make much impression upon the iron and steel market, but it has had the effect of reducing the stocks of material in the works yards and brought the time when consumers must perforce re-enter the market for fresh supplies nearer. As far as buying and selling was concerned, there was not much activity to-day, and few new contracts were entered into. As a matter of fact, contracts which were made three months ago, and which should have been completed by now, are still uncompleted, manufacturers having been unable to take material at the rate forecast by them when the year opened. Specifications have been below normal for many weeks, and blast-furnacemen and steel rollers find themselves at the opening of a new quarter with a fair reserve of orders on the books, though they have received few fresh contracts. The position, therefore, can hardly be considered satisfactory. Though demands upon producers have been better during the past week, they are still of a disappointing nature, being for very small tonnages of material, enough to cover only immediate needs. There is not sufficient view ahead to justify iron and steelmasters buying forward, but many Black Country users of foreign material have taken the precaution to get in relatively large stocks, as they calculate upon higher prices ere long. Foreign iron and steel finds its way into this area week by week, but it is mostly on account of orders placed some time ago. Birmingham merchants report that there have been few fresh contracts made recently, users having gone as far as they consider prudent in the matter of commitments. Conversations on 'Change to-day favoured the opinion that there will be a much better chance for the sale of British iron and steel during the current quarter. It is admitted that the partial inertia existing in the heavy industries shows little or no signs of giving way as yet, but the increased briskness noticeable in automobile engineering, in the light metal working industries, in heavy edge tool production, and in one or two other directions, encourages the belief that trade is on the road to progress and that the second quarter will see some definite advance along the highway.

Blast-furnace Production.

Derbyshire and Northamptonshire producers of pig iron have substantial contracts on their books, but specifications against these are very poor, and it will take much longer than was anticipated to work off the contracts on hand. A little material is being bought on the open market, and forge and foundry grade iron sells at recent price levels. Derbyshire and North Staffordshire No. 3 foundry pig is £3 6s. per ton, delivered to stations in this area, Northamptonshire No. 3 foundry is £3 2s. 6d. per ton. Forge grades continue to be quoted 5s. per ton below the figure for their respective foundry materials. These quotations are precisely the same as those current at the first quarterly gathering this year. Smelters are not so well placed for work as they were then. The past quarter was disappointing and the indications for the second three months of the year are not very cheerful.

Lifeless Steel Market.

The steel department of the market was this week almost devoid of life. There is practically no business passing, either in native or foreign finished or semi-finished steel, and where steelmasters and their clients were gathered together the chief topic of conversation was tariffs. The probability of the steel industry being placed on a more competitive footing with foreign rivals was what all were concerned with, and it was quite evident that until the position as to an additional protective duty is known there will be little market activity. Finished steel was this week quoted at late rates, as were half-products. Foreign steel was offered at prices lower than were acceptable a week ago, but there were no buyers. Consumers in this district have laid in stocks of Continental steel sufficient to last them for some time at the present rate of consumption, and they are not prepared to commit themselves further. Indeed, so large are accumulations of foreign steel that it must take months before even an increased tariff could take effect in reducing the actual consumption of Continental steel and increasing the demand for British material. Inquiries amongst steel users on 'Change in Birmingham this week failed to reveal much prospect of increased consumption. The demands for special steels for automobile engineering show improvement and are likely to grow, but large steel users such as constructional engineers, rolling stock makers, and the like, all report business as quiet and likely to remain so as far as they can see. Steel quotations are as follows: Angles, £8 7s. 6d.; tees, £9 7s. 6d.; joists, £8 15s.; ship, bridge and tank plates, £8 17s. 6d., all per ton and less their respective rebates; boiler plates, £8 10s.; small steel bars re-rolled from foreign material, £6 7s. 6d.; all-British bars, £7 5s. upwards; mild steel billets, £5 5s. to £5 7s. 6d.; sheet bars, £5 to £5 5s.; Staffordshire hoops, £9 10s.

Finished Iron.

The finished iron trade in this area is in much the same position as on last Quarter Day. Business is no brighter, order books are no thicker, selling prices are unchanged and the outlook remains obscure. Makers of iron strip are in a slightly worse position than they were, three months ago, for in this department there is less business on hand and values are lower by about half-a-crown per ton. There are a few firms which still quote £10 12s. 6d. per ton, but the market level is no higher than £10 10s., which was the minimum figure named last Quarter Day, when business was put through at up to £10 12s. 6d. Staffordshire ironmasters are unable to keep all their plant in operation and they rely upon booking some good orders at the Spring Meeting to-day to enable them to maintain even the present rate of output. Marked bars are quoted at £12 per ton at makers' works, Crown bars at £9 5s. upwards, common bars, for the nut and bolt and fencing industries, at £8 7s. 6d., and wrought iron tube strip at £10 10s. Foreign No. 3 iron, which competes with Staffordshire common bars, is on offer at a lower figure than before the general 10 per cent. tariff was imposed. Consumers have stocks and there is consequently no demand for fresh supplies.

Galvanised Sheets.

The progress reported to have been made in the galvanised sheet industry last week has been about maintained, and inquiries, especially from the East, encourage the belief in further improvement during the next few weeks. Local mills are moderately well engaged, and selling prices are firm on the basis of £9 10s. per ton for 24 gauge galvanised corrugateds. The home demand also keeps up well and is considered satisfactory under existing circumstances. Selling prices of sheets have risen during the quarter from £9 to £9 2s. 6d. in some cases, to the present level of £9 10s. minimum.

Coventry Engineering.

There is a brighter trade outlook at Coventry and unemployment is much less than it was a month or so ago. The city's premier industry, automobile engineering, is picking up considerably, and a number of light car firms are working at almost full pressure. There is also considerable liveliness in the aircraft and aero engine industries, while machine tool makers are moderately well employed. Inquiries in circulation throughout the respective industries encourage hope of further progress in the near future.

All-metal Omnibuses.

All-metal double-deck omnibuses are to be used in the near future in the Midlands. An order for ten 52-seater double-deck omnibus bodies of special all-metal construction is stated to have been placed by the Birmingham and Midland Motor Omnibus Company, Ltd., with the Metropolitan-Cammell Carriage, Wagon and Finance Company, Ltd., of Saltley, Birmingham. The vehicles are lighter in weight than those made of other material. Trial trips with single-deck all-metal bodies have proved satisfactory, and it is anticipated that the new vehicles will give equal satisfaction.

Design in Industry.

Much interest has been displayed in the exhibition in Birmingham promoted by the Birmingham Group of the Design and Industries Association. The exhibition, which was not open to the general public, was on a small scale, and comprised a collection of articles sent in by about a score of firms, the idea underlying it being that of discovering whether by constructive suggestion and co-operation any practical improvement can be made in the design of specific articles without increasing their cost or decreasing their saleability. The specimens on view afforded evidence that in these days of mass production the artistic design of articles of everyday use has not altogether been neglected.

Manufacturers and Trade Obstacles.

Midland manufacturers, members of the National Union of Manufacturers, discussed the difficulties of trade at a meeting in Birmingham on Monday, and suggestions were made as to the best means of overcoming them. Obstacles that face the British manufacturer, as the result of world turmoil, were enumerated by Mr. Wilfrid Hill, who suggested scientific management as a panacea.

Birmingham Chamber of Commerce.

Mr. Peter F. Bennett, managing director of Lucas's Ltd., has been elected President of the Birmingham Chamber of Commerce and has been invested by the retiring President, Mr. E. W. Bache, with the chain of office. Mr. W. L. Chance and Mr. T. J. Kennedy have been elected Vice-presidents, and Mr. Frank Wain re-elected treasurer.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

The Fall in Unemployment.

In common with the rest of the country, unemployment has declined in the Lancashire district, but the process of improvement is a slow one. This is particularly the case so far as the engineering trades generally are concerned, although in most branches the position is better than it was twelve months ago. The complaint of iron and steel trade interests, however, is that up to the present the increase of employment in Lancashire has not been reflected in any notable expansion of the demand for the products of the iron and steel industries. The incidence of unemployment in the county has a remarkably wide range, and varies from as low as 5·1 per cent. in the favourably situated Leyland, with its important motor vehicle industry, to the maximum of 43 per cent. in Great Harwood, a "cotton town," whose misfortunes have grown with the development of the boycott movement in India. At 15·8 per cent., Manchester occupies a not unfavourable position, having regard to the depression in several of its primary industries, including engineering, with Salford much worse situated at 24 per cent., and Liverpool at 28·3 per cent. The improvement has been most marked in the districts which are essentially coal-mining centres, with a less pronounced improvement in the chief cotton manufacturing areas.

A New Industry.

Next to Great Harwood, Mossley, with an unemployment percentage of 42·4, has been the worst hit by the industrial depression, but there appears now to be a very definite prospect of a revival of the town's fortunes. The local Industrial Development Committee has succeeded in disposing of two cotton mills which are to be reorganised and adapted to the needs of a new textile industry, the exact nature of which has not yet been disclosed. From the point of view of Mossley, the important factor is that rather more than 1000 of the town's unemployed workpeople will be absorbed. The existing machinery of the two mills is to be replaced by new plant for the special purposes required.

Electricity for Irlam.

The electricity supply scheme for Irlam has now been completed at a cost of about £103,000 and current has just been made available to the district, where the principal plant of the Lancashire Steel Corporation, Ltd., is situated. The electricity scheme has been sponsored by the Stretford and District Electricity Board.

Order for Heavy Oil-engined Omnibuses.

One of the latest orders received by Crossley Motors, Ltd., Manchester, for motor omnibuses fitted with oil engines is for twenty double-deck vehicles for Portsmouth Corporation.

Obituary.

Mr. James Henry Ward, a director of Ward and Goldstone, Ltd., electric cable and accessory manufacturers, of Pendleton, near Manchester, died at his residence, "Mayfield," Alexandra Park, Manchester, on Friday last, at the age of sixty-five years.

Non-ferrous Metals.

Almost general weakness throughout the non-ferrous metals has been the feature of the past week's operations, spelter being the only section to be able to resist the further downward pressure. Tin, however, has been the chief centre of interest, for, for the third successive week, there has been a very severe loss on balance. The past week's fall in the price of the metal of roughly £7 per ton, following upon losses of about £9 in each of the previous weeks, has brought current values of foreign tin to little more than £100 per ton. As a matter of interest, it may be recalled that as recently as two months ago the corresponding quotation was in the neighbourhood of £141 per ton. The supply position in relation to the demand for the metal is, of course, still the principal "bearish" factor, although difficulties of a financial character are said to have been also at work during recent weeks. The decline in copper goes on without interruption, prices current about the middle of January being almost 50 per cent. above those now ruling for standard brands of the metal. At one time during the past week a slight improvement in the volume of business in refined descriptions was experienced on the home market, but the expansion was short-lived, and trading conditions are again dull, with interest on the part of United States and Continental consumers also on an unsatisfactory scale. Much of the moderate turnover on the home markets has been on account of speculators, and the immediate outlook is no more cheerful than it was before. Compared with last report, quotations for standard cash metal are lower to the extent of about 25s. per ton. A decline of a further 5s. per ton on the lead market has brought prices of the English metal to about £13 per ton, which compares with a recent top figure of £17. Lead users are not adding very much to the stocks they have already bought, although at the present low prices rather more active buying has been reported on the American markets. The demand for spelter has been on a moderate scale, with current values somewhat higher than they were a week ago.

Iron and Steel.

Considerable interest has been aroused on the iron and steel markets by the rumoured intention to increase the tariff on iron and steel materials, but it has had no influence on trading conditions on the markets here, for the very definite view is that conditions at the consuming end rather than the price factor are responsible for the unsatisfactory demand for all classes of products that is being experienced. In the case of pig iron, the movement into consumption has been about maintained, but sellers again report very little new buying interest. Prices, however, keep up at 67s. per ton for Staffordshire, Derbyshire, and North-East Coast brands, 65s. 6d. for Northamptonshire, about 86s. 6d. for Scottish, and 81s. for West Coast hematite, all for delivery in the Manchester district. There is only a comparatively retail business passing in bar iron, especially in the nut and bolt-making grades, but there has been no change in the price situation, Lancashire best bars being on offer at £10 5s. per ton, and Crown quality material at £9 15s. In the steel market locally, there is a disappointing absence of any indication of revival in the demand for structural, boilermaking, and locomotive-building descriptions. There is a moderate call for small bright drawing bars, but in other respects the bar trade also is very quiet. Prices of home-manufactured goods are firm, but further important reductions have occurred in imported descriptions, without, however, any appreciable interest from buyers.

BARROW-IN-FURNESS.

Hematite.

Despite many rumours, there is still a lack of evidence of any convincing improvement in the hematite pig iron trade in this district. A few inquiries have been received, and it is possible that there may be a few more shipments overseas, but there is nothing to show that a turn in trade has arrived. Recently, shipments to the Continent have been very low indeed. The home trade continues on the same lines, practically speaking, and the total business is small. In six weeks it may be possible to say which way trade will be turning. With local steel departments idle, there is very little demand for iron for conversion, and stocks are therefore being tapped and in most cases being gradually reduced. It is possible that another furnace or two will be restarted in a few weeks, but at present there has been no official statement, and this points to the fact that business is still very uncertain. As regards the iron ore trade there is very little business being done, for the local requirements are very low, and the tonnage going out of the district is light. The steel trade continues to be flat and fresh orders would be very welcome. They would encourage makers to restart sooner on small contracts already held.

SHEFFIELD.

(From our own Correspondent.)

Conditions Unchanged.

There is little alteration in the state of trade in the local steel industry. Production of open-hearth steel is restricted, and even so, difficulty is experienced in finding a market. It is obvious that consumers of steel material are pursuing a policy of caution and economy, merely ordering to meet immediate requirements. This is reflected in the smallness of individual orders. At the same time, there is increased activity in the finished trades, and some firms are doing good business in special lines. It is reported that production of steel ingots and castings in the Sheffield area during February amounted to 69,200 tons, compared with 62,300 tons in January and 97,500 tons in February last year. The total included 39,700 tons of basic and 21,700 tons of acid steel. The Lincolnshire figures for the same month were 35,300 tons, compared with 31,400 tons in January and 34,800 tons in February last year.

Nickel Steel Plates.

The works of the United Steel Companies, Ltd., at Appleby in North Lincolnshire, are now manufacturing nickel steel plates in all sizes, from ¼in. thick upwards. Previously, these works have only made mild and medium carbon steels for boiler, ship, bridge, tank, and structural purposes. The development is an indication of the increasing use of alloy steels in general engineering and of the desire to take advantage of the higher stresses for which these materials are useful, while at the same time reducing weight. Nickel steel plates are in extensive use for automobile and heavy vehicle chassis frames, brake drum pressings, as well as for structural engineering purposes, bridge, and railway work.

The Salerni Process.

It is reported that steady progress is being made with the practical development of the scheme for the production of smokeless fuel and oil by the Salerni process. Contracts have been placed with British firms for the erection of plant in Sheffield, but it is understood that work will not be started for at least six months. Three sites are under consideration and the final decision will be made by Professor R. V. Wheeler, of Sheffield University, who has been associated with Commendatore Salerni in the development of the process. Commendatore Salerni is visiting Sheffield practically every week in connection with the scheme, which has aroused great interest abroad, inquiries having been received from many countries, including Russia.

Corrosion-resisting Steels.

Important experimental work in connection with heat and corrosion-resisting steels has been carried out in the research laboratory of Hadfields, Ltd., at Sheffield. These steels are now used to a very wide extent, and the fact that they have found important uses in the chemical industry indicates a great metallurgical advance. The steels have also been used extensively in the smelting of zinc, lead, antimony and tin. Before the war the chemical industry got its supplies of special steels almost wholly from Germany. During the war this source of supply being unavilable, Sheffield met the demand, and in recent years the manufacture has been greatly improved. The new steels have made the production, storage, and transporation of nitric acid, for instance, very much simpler and cheaper than in the past. Another specialty of Hadfields is the manufacture of heat-resisting steels, some of which can withstand temperatures of over 1100 deg. Cent.

Cutlery and Plate.

Manufacturers of cutlery and plate are experiencing a very lean time, and the tendency seems to be for business to decline rather than improve. Some lines are doing well, however, and considerable quantities of spoons, forks, scissors, and safety razor blades are being produced and sold. The firm of G. Richarty, of Solingen, Germany, has acquired premises in Broomhall-street, Sheffield, for the manufacture of pocket cutlery. The plant required has been brought from the Solingen works to Sheffield, and is now being installed.

Rotherham Gasworks.

Extensions of the Rotherham Corporation gas department, completed at a cost of £25,000, have been formally opened. Gas was first manufactured in Rotherham in 1833 by a private company, from which the Local Board purchased the undertaking in 1870 for £53,455. Since that date considerable expansion has taken place, involving capital expenditure which had reached £328,834 in 1931. In 1918 the Corporation secured parliamentary powers to purchase and distribute coke oven gas, and supplies have since been taken in increasing quantities. In 1928 it was decided to close down the Corporation's gas-making plant and to meet the whole of the town's requirements with purified coke oven gas. During recent years there has been a rapidly growing demand for supplies of crude gas for industrial purposes, particularly for furnace heating. The new department serves an area of 30 square miles, with a population of more than 100,000.

NORTH OF ENGLAND.

(From our own Correspondent.)

Brighter Outlook.

The outlook generally in the North of England iron and steel trade is regarded as distinctly brighter. Improvement is slow, it is true, but some expansion in the volume of business has been experienced this week, and anticipations of the early imposition of an increased tariff are creating lively expectations that an era of increased activity is at hand. Foreign business is still very difficult to book, but the home market has been so seriously invaded that the exclusion of foreign material would give a big impetus to the British iron and steel industry. Operations are being increased at some of the steel works. Additional orders for steel billets resulted in the Consett Iron Company's angle mills, Durham, starting on Sunday night, this being the first time they have started on a Sunday since 1925. Three shifts daily are now being employed at the works instead of the usual two.

Miners Withdraw Notices.

The miners at Ryhope Colliery, who had decided upon strike action against the employment of non-union labour, withdrew their notices on Monday. More than 100 men were recently dismissed, owing to the closing down of a seam in the West Pit, and as all were members of the lodge, the agent to the company was requested to reinstate some of them and dismiss the fifty odd non-unionists at the colliery. This he refused to do, and the men decided to hand in their notices. Towards the latter part of last week it was reported that the company was refusing orders, owing to its inability to guarantee delivery because of the threatened stoppage. It was also declared that in the event of a stoppage, the manager would reserve the right to restart whom he liked when work was resumed. It became apparent to the men that they would receive no financial assistance from the Durham Miners' Association, and that their claim for unemployment benefit would be refused. Faced with this situation, a large number of men withdrew their notices, and the others followed suit after a lodge meeting.

Cleveland Iron Trade.

In the Cleveland pig iron trade contracts are nearly all for limited periods, but the output is being absorbed, and in spite of severe competition sales are on a heavier scale to Scotland. There is also a little more inquiry from other sources, and a more hopeful tone is developing. Very little export business is possible. There is no hint of price concessions, and apart from the more favourable terms offered to Scottish consumers, the fixed minimum prices are:—No. 1 Cleveland foundry iron, 61s.; No. 3 G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s.

Hematite Pig Iron.

East Coast hematite sales no more than balance output, but prices have stiffened, and 63s. 6d. is now a firm figure for mixed numbers, with No. 1 quality at 64s.

Iron-making Materials.

The foreign ore market is wholly idle, and 15s. 6d. c.i.f. Tees is a purely nominal figure for best Rubio ore. Sellers of blast-furnace coke quote 16s. delivered at the works, but they have heavy stocks, and in some cases would shade that figure.

Manufactured Iron and Steel.

Overseas trade in manufactured iron and steel is on a better scale, and during the past few days further cargoes have been shipped from the Tees, both to Russia

and Canada. Home demand is also expected to improve, and prices are firm.

The Coal Trade.

The prospects in the Northern coal trade do not seem to improve, and idle time is being experienced at many pits. It is on the Durham side of the Tyne that trade is mostly wanted, and once again miners in some districts have had to be given notice, owing to the slackness of orders. The import restrictions on the Continent are telling more against Durham coals than Northumberlands. Foreign importers are greatly opposed to the limitations, but their protests have seemingly not been of any avail so far. Most industrial coals are produced in Durham, and they are feeling the restrictions abroad severely. Northumberland is not affected in the same way, and continues to do a good coasting trade, supplemented by more orders from Northern Europe, consequent upon less severe competition from Poland. A good deal is being heard of the possibilities of greater trade with Canada. A big cargo was shipped from the Tyne this week, and some fitters are of the opinion that more business is coming. At the present low rate of freights and under devalued sterling, North-East coal can be delivered to Canadian ports at a lower price than that of American coal, which has very long railway leads. At the same time, it is said that American coal is subject to less breakage, owing to being carried by rail, than is English coal, which may in certain circumstances suffer breakages when being put into the ship and taken out again at the place of discharge. Future increase in the trade will depend on three main points—the condition of the coal on arrival, its suitability for particular purposes, and the competitive price. The recent pressure for Northumberland steam coal has fallen away to some extent, and fitters are anxious to secure additional business for this month. The output at present is maintained, but prospects ahead are not so bright, and work at the pits may have to be curtailed. Prices are unchanged, but nominally easier in tone, best large at 13s. 6d. and small at 8s. 6d. Prime Wear steams are also offering in good volume, large at 15s. and small at 12s. Tyne prime large are steady at 13s., with small firm at 9s. There are no signs of interest in any section of the Durham coal market. Shipments of gas coal to Germany are practically at a standstill, owing to the severe restrictions of imports into that country. Gas qualities are plentiful at 14s. 6d. for best qualities and 13s. 3d. to 13s. 6d. for secondary kinds. Durham coking unscreened fuels have a slow movement at 13s. to 13s. 9d. Coking smalls are moderately active at the schedule minimum of 12s. 6d. to 13s. 3d. Bunker coals are irregular in tone. The demand for best is falling off, but quotations remain at 13s. 6d. to 14s. Secondary sorts are easy at 13s. The inquiry for coke of any description is meagre. Scandinavian shipments are being checked by the fluctuation in sterling exchange, and in other centres consumers show no interest. Gas coke is in good supply at 18s. Patent oven coke is obtainable at lower values, good grade at 14s. 6d. and superiors at 18s. to 20s.

Wages Unchanged.

For the next three months the wages of Cleveland ironstone miners will continue unaltered. The wages of the workers in the Weardale limestone quarries will also remain unchanged. The wages are fixed by a sliding scale, and vary in accordance with the ascertained selling price of Cleveland pig iron. Compared with the figure for the previous three months, this had changed only by a small fraction of a penny.

SCOTLAND.

(From our own Correspondent.)

Dull Markets.

THE steel, iron, and coal markets have very little fresh business. Requirements generally at home and abroad continue on a most restricted basis, and there is little immediate prospect of expansion.

Steel.

Conditions in the heavy steel industry fail to show any improvement. The continued scarcity of specifications for shipbuilding material is a heavy handicap, the extent of which may be realised from the statement that only about 14 per cent. of the slips in British shipyards are occupied at present. Plate mills are poorly situated, and employment is most irregular. The demand for structural steel is moderate.

Sheets.

Thin sheets have a fair export inquiry and some comparatively good orders have been reported. Heavy sheets are somewhat neglected, but makers anticipate the placing of orders for Canada. Business in galvanised sheets is uneven.

Tubes.

Though the contract for tubes secured by Stewarts and Lloyds, in connection with the development of the Irak oilfields, will provide a considerable amount of employment, the general demand continues on most restricted lines. It is hoped, however, that the continuance of the international Cartel will lead to improved demands.

Steel Contract.

It is reported in connection with the Irak oilfields development that Redpath, Brown and Co., Ltd., of London and Edinburgh, have received an order for the steel material for sixty-three buildings, including bungalows, garages, and a hospital. The quantity of steel required will amount to about 1800 tons.

Iron.

Bar iron still suffers in competition with Continental material and steel bars of home and foreign manufacture. Makers, however, are hopeful that Canada will be a larger buyer this season, though prospects in other directions are not expected to improve. Re-rolled steel bars are quiet and considered an unremunerative proposition at £6 5s. home and £6 2s. 6d. per ton export. Scrap shows hardly any movement at 37s. 6d. for heavy steel and 50s. to 52s. 6d. per ton for cast iron machinery.

Pig Iron.

The number of furnaces in blast in Scotland remains at six, and supplies are still ample. Further quantities have arrived in this district from abroad and across the border, 3000 tons having arrived from Calcutta and 400 tons from Workington. Shipments of pig iron from the Clyde last week amounted to 390 tons (41 tons foreign), compared with 125 tons (110 tons foreign) in the same week last year.

Coal.

The inquiry for Scottish coal from all sources is restricted. Home requirements for gas, electricity and household purposes are comparatively small. Deliveries of fuels for industrial purposes are also restricted. The shipping department is adversely affected by Polish competition, licensing systems, restriction of imports abroad, and import duties on cargoes to certain Continental countries. The efforts of the Government to induce Germany to remove the restrictions on imports into that country are being eagerly followed in the hope of a satisfactory conclusion. Collieries in the Lothians and Fifeshire are especially affected by the lack of shipping orders. Meantime, only small prompt lots are sold forward, transactions being impossible unless cheap prices are conceded. All fuels, especially washed materials, are plentiful, and prices are weaker. Aggregate shipments amounted to 211,723 tons, against 211,696 tons in the preceding week, and 201,384 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Coal Trade.

SHIPMENTS from South Wales last week were by no means unsatisfactory, as the total, according to the returns of the Great Western Railway Company, was 415,100 tons, which compared with 268,180 for the previous week, while for the corresponding period of last year the quantity was 315,352 tons, but it must be pointed out that that period included holidays. Still, the figures for last week are interesting, inasmuch as shipments of coal from Cardiff were the highest for this year, while Swansea created a record also for 1932, as the result of the activity prevailing in the shipment of anthracite coals to Canada. It is perhaps a little surprising in view of these facts to find that last week finished up with the number of vacant loading berths at the high level of forty-five, while there was only one steamer waiting to load. It is too much to expect last week's total of shipments to be maintained, even though chartering has recently been fairly good. Last week tonnage fixed to load at South Wales ports came to nearly 220,000 tons carrying capacity, but this is not all for prompt loading, and unfortunately this week there has been a decided falling off in the activity on the chartering market, so that the outlook cannot be described as promising. As a matter of fact, this week opened with the number of vacant loading berths at twenty-five, and only two steamers waiting for a berth, while on Tuesday the position was less favourable, as the total number of vacant berths rose to thirty-two with only one steamer waiting. There can be no doubt that collieries are working very irregularly, and it is not only that prompt orders are scarce, but wagons are at a premium, owing to the excessive stocks of small coals for which the demand is negligible. Requirements for foreign coaling depôts are very restricted, while new inquiries from consumers abroad are less than for some time past. The restrictions placed on the import of British coals are responsible for the diminished activity in some directions, while in others the question of foreign exchange is an adverse factor, particularly in the case of Spain, where the peseta is in the neighbourhood of 50 to the pound sterling.

Italian and Brazilian Business.

Reference was recently made to the fact that an order for 75,000 tons of steam coal for the Brazilian Central Railways has been lost by this district, and had been secured by German suppliers in consideration of Germany taking supplies of Brazilian coffee, the German quotation for coals being 3d. per ton less than the figure quoted for Welsh coals. Since then news has come to hand which shows that the position from the point of view of supplying the Brazilian Central Railways with coal is worse than was realised at the time, as it is understood that the supply of German coals is to be increased by at least 200,000 tons in consideration of the German Government guaranteeing to increase its importation of coffee by an equal amount. The effect of this is that the Brazilian Central Railways will practically be out of the market for coals for the remainder of this year, and the loss of such a substantial amount of business means no work for round about 1500 miners from now to the end of the year. Anxiety is also felt regarding the absence of any news about the placing of contracts by the Italian Government for supplies of coal for the Italian State Railways for the current year. It will be recalled that under the Hague agreements the Italian Government undertook to take from this country 1,000,000 tons of coal annually for three years. This scheme operated from 1930, but during the latter half of last year the quantities taken by Italy were considerably curtailed, owing to the heavy stocks in Italy and the Italians' desire to reduce them, with the result that it is only now that they are completing the shipment of the 1931 quantity. Up to now, no steps have been taken for arranging for this year's supplies, and failure to do so is causing anxiety in colliery circles, more particularly to Monmouthshire collieries, from which the coals are drawn. Actual inquiries on the market are comparatively insignificant. The Palestine Railways are open for 6000–7000 tons of steam coal, for which tenders have to be in on the 18th inst.; whilst the Jamaican Railways have asked for prices for a cargo of 6000 tons, for which tenders have to go in on the 14th inst.

Shipping.

Conditions prevailing on the freight market are just about as bad as they can be, and rates are the lowest for some time past. It is not surprising, consequently, that the amount of tonnage laid up should be considerable. According to the latest returns available, there were seventy vessels, aggregating 316,335 deadweight tons, laid up at the South Wales docks, under the control of the Great Western Railway Company, on April 1st. Of these vessels, fifty, of 219,392 tons deadweight, belong to South Wales owners, and it must be remembered that a number of locally owned steamers are laid up at other ports in the United Kingdom. Compared with January 1st, the laying-up returns on April 1st show an increase of thirteen vessels, of 16,091 tons net, representing a deadweight capacity of 40,227 tons. The total of vessels laid up on April 1st showed, however, a slight reduction as compared with the returns for April 1st, 1931, as at that time the number of vessels was seventy-nine, of 392,900 tons deadweight.

Cardiff as an Air Port.

News is awaited this week from the Air Ministry as to its decision regarding the application for a licence for the Cardiff municipal aerodrome at Splott tidefields. An aeroplane hangar to hold six or eight aeroplanes is to be constructed, and tenders have been asked for by the Cardiff Corporation. The existing hangar is only large enough for one aeroplane.

Current Business.

The tone of the steam coal market is, if anything, quieter, and the conditions are rather depressing. The home demand for coals is by no means satisfactory, and the foreign inquiry displays contraction instead of expansion. The position of collieries varies very materially, but by far the greater number have difficulty in avoiding temporary stoppages. Prices all round remain at the minimum level, with dry qualities relatively steadier than other descriptions. Patent fuel is without perceptible change, and coke is steady, but pitwood is slow at prices ranging from 18s. 9d. to 20s. 6d. Reference has previously been made to the fact that Portugal had proved a very serious competitor with France in this business. Returns for March show that imports of pitwood from Portugal had established a record, the quantity being 46,959 loads, which compared with 39,421 loads for the preceding month and with 10,410 loads for the corresponding period of 1931. On the other hand, whereas imports of pitwood into South Wales from France during March last were 25,758 loads and in February 24,719 loads, the quantity for March, 1931, was 63,965 loads.

Big Order for South Wales.

The announcement that the British Mannesmann Tube Company, Ltd., has been allotted a considerable share of the order for the pipe line which is to carry oil from Irak to Mediterranean ports, a distance of some 1200 miles, has caused considerable satisfaction in South Wales.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

REDFERN'S RUBBER WORKS, Ltd., have removed their London depôt to Redfern House, 212–214, Great Portland-street, W. 1. Telephone number, Museum 0381; telegraphic address, "Berrub Wesdo."

SPECIALLOID, Ltd., Friern Park, North Finchley, N. 12, informs us that it has changed its Glasgow office from 178A, Bath-street, and has established new offices and stores at 134, Wellington-street.

YARROW AND CO., Ltd., Scotstoun, Glasgow, W. 4, inform us that William Denny and Brothers, Ltd., Dumbarton; The Wallsend Slipway and Engineering Company, Ltd., Wallsend; and Hawthorn, Leslie and Co., Ltd., Newcastle, have just taken out long-term licences to manufacture the latest forms of Yarrow high-pressure water-tube boilers.

CATALOGUES.

BROOKHIRST SWITCHGEAR, Ltd., Chester.—Brochure on the automatic control of street lighting.

BRITISH RADIOSTAT CORPORATION, Ltd., 29, George-street, W. 1.—A brochure on the "Stenode" system of voice-frequency telegraphy.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C. 2.—Catalogues of conduits and conduit fittings and electric light supplies.

NEVILLE'S (LIVERPOOL), Ltd., 107–109, Gray's Inn-road, W.C. 1.—Illustrated brochure of coil winding and taping machines, vacuum impregnating plant, &c.

JAMES KEITH AND BLACKMAN COMPANY, Ltd., 27, Farringdon-avenue, E.C. 4.—Booklets on "Keith Rotary Compressors for Air or Gas" and "Blackman Volume Fans."

BRITISH CHEMICAL STANDARD ALLOY STEEL "W 2."—British Chemical Standards, 3, Wilson-street, Middlesbrough, announces that a renewal of high-speed alloy steel "W" having the following standardised analysis has been made: Carbon, 0·17 per cent.; silicon, 0·14; sulphur, 0·051; phosphorus, 0·026; manganese, 0·22; chromium, 3·29; vanadium, 0·82; tungsten, 16·12; cobalt, 4·35; nickel, 0·43; molybdenum, 0·55 per cent. It will be noticed that in addition to the alloy elements which were in the original standard "W," the renewal contains molybdenum which now seems to be frequently used. The standard will be useful for checking all high-speed steel analyses, also cobalt magnet steels, chrome-molybdenum steels, &c. The "standard" is sold in units of 25 grammes, 50 grammes, 100 grammes and 500 grammes, at a price which it is estimated will eventually cover the cost of preparation.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
(1) Native	16/6 to 20/–
(1) Spanish	17/– to 22/6
N.E. Coast—	
Native	18/– to 21/–
Foreign (c.i.f.)	15/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	3 8 6	—
No. 1 Foundry	3 12 0	—
No. 3 Foundry	3 9 6	—
N.E. Coast—		
Hematite Mixed Nos.	3 3 6	3 3 6
No. 1	3 4 0	3 4 0
Cleveland—		
No. 1	3 1 0	3 1 0
Siliceous Iron	3 1 0	3 1 0
No. 3 G.M.B.	2 18 6	2 18 6
No. 4 Foundry	2 17 6	2 17 6
No. 4 Forge	2 17 0	2 17 0
Mottled	2 16 6	2 16 6
White	2 16 6	2 16 6
Midlands—		
(c) Staffs.—	(*Delivered to Station*).	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 1 0	—
„ „ Foundry	3 6 0	—
(c) Northampton—		
Foundry No. 3	3 2 6	—
Forge	2 17 6	—
(c) Derbyshire—		
No. 3 Foundry	3 6 0	—
Forge	3 1 0	—
(3) Lincolnshire—		
No. 3 Foundry	—	—
No. 4 Forge	—	—
Basic	—	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	3 15 6 (*a*); 4 0 6 (*b*); 4 5 6 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	9 15 0	9 5 0
Best	—	—
N.E. Coast—		
Iron Rivets	11 5 0	—
Common Bars	10 0 0	—
Best Bars	10 10 0	—
Double Best Bars	11 0 0	—
Treble Best Bars	11 10 0	—
Lancs.—		
Crown Bars	9 15 0	—
Second Quality Bars	8 5 0	—
Hoops	12 0 0	—
S. Yorks.—		
Crown Bars	9 15 0	—
Best Bars	10 15 0	—
Hoops	12 0 0	—
Midlands—		
Crown Bars	9 5 0 to 10 7 6	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 7 6	—
Gas Tube Strip	10 10 0	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates (Marine)	9 0 0	8 10 0
„ „ (Land)	—	—
Ship Plates, ½in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	7 15 0	7 15 0
Sheets (Gal. Cor. 24 B.G.	10 15 0	10 0 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 15 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	7 2 6	—
Soft Billets	5 10 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	6 10 0 to 9 0 0	—
Manchester—		
Bars (Round)	9 7 6	—
„ (Small Round)	7 0 0	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	8 12 6	—
Sheffield—		
Siemens Acid Billets	9 2 6 (basis)	—
Hard Basic	8 2 6 and 8 12 6	—
Intermediate Basic	6 12 6 and 7 2 6	—
Soft Basic	6 0 0	—
Hoops	9 10 0 to 9 15 0	—
Soft Wire Rods	7 10 0	—
Midlands—		
Small Rolled Bars (all British)	7 5 0 to 7 15 0	—
Small Re-rolled Bars	6 7 6 to 6 10 0	—
Billets and Sheet Bars	5 5 0 to 5 10 0	—
Galv. Sheets, f.o.b. L'pool	9 10 0	—
(3) Staffordshire Hoops	9 10 0	—
(*d*) Angles	8 7 6	—
(*d*) Joists	8 15 0	—
(*d*) Toes	9 7 6	—
(*d*) Bridge and Tank Plates	8 17 6	—
Boiler Plates	8 10 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14 f.o.b.	16/–
Block Tin (cash)	102 5 0
„ (three months)	104 10 0
Copper (cash)	29 5 0
„ (three months)	29 10 0
Spanish Lead (cash)	11 0 0
„ „ (three months)	11 5 0
Spelter (cash)	11 0 0
„ (three months)	11 7 6
Manchester—	
Copper, Best Selected Ingots	34 5 0
„ Electrolytic	35 0 0
„ Strong Sheets	63 0 0
„ Tubes (Basis Price), lb.	0 0 9½
Brass Tubes (Basis Price), lb.	0 0 9
„ Condenser, lb.	0 0 11½
Lead, English	13 2 6
„ Foreign	11 5 0
Spelter	11 10 0
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

		Per Ton.	Per Unit.
Tungsten Metal Powder	2/4 per lb.		
Ferro Tungsten	2/– per lb.		
Ferro Chrome, 4 p.c. to 6 p.c. carbon		£26 8 6	7/–
„ „ 6 p.c. to 8 p.c.		£23 10 0	7/–
„ „ 8 p.c. to 10 p.c.		£23 0 0	6/6
„ „ Specially Refined			
„ „ Max. 2 p.c. carbon		£40 0 0	10/–
„ „ „ 1 p.c. carbon		£55 0 0	12 –
„ „ „ 0·70 p.c. carbon		£57 10 0	13/–
„ „ „ carbon free	11d. per lb.		
Metallic Chromium	3/1 per lb.		
Ferro Manganese (per ton)	£11 0 0 for home		
„ „ „	£11 10 0 for export		
„ Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/– per unit		
„ „ 75 p.c.	£17 15 0 scale 7/– per unit		
„ Vanadium	12/9 per lb.		
„ Molybdenum	6/3 per lb.		
„ Titanium (carbon free)	9d. per lb.		
Nickel (per ton)	£250 to £255		
Ferro Cobalt	10/– per lb.		

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	13/– to 13/3
„ „ Ell	14/3
„ „ Splint	14/– to 15/9
„ „ Trebles	12/–
„ „ Doubles	10/–
„ „ Singles	8/9
Ayrshire—	
(f.o.b. Ports)—Steam	13/–
„ „ Jewel	16/6
„ „ Trebles	12/3
Fifeshire—	
(f.o.b. Methil or Burnt island)—Steam	11/– to 12/–
Screened Navigation	16/6
Trebles	12/– to 12/6
Doubles	10/–
Singles	8/9
Lothians—	
(f.o.b. Leith)—Best Steam	11/– to 11/6
Secondary Steam	10/9 to 11/–
Trebles	11/– to 11/6
Doubles	10/–
Singles	8/9 to 9/–

(8) N.W. Coast— ENGLAND.

Steams	21/9
Household	32/6 to 51/8
Coke	20/– to 22/6
Northumberland—	
Best Steams	13/6
Second Steams	12/3 to 12/6
Steam Smalls	8/6
Unscreened	12/6 to 13/–
Household	27/– to 39/–
Durham—	
Best Gas	14/6
Second	13/3 to 13/6
Household	25/– to 37/–
Foundry Coke	24/–

Sheffield—	Inland.	
Best Hand-picked Branch	26/6 to 27/6	—
South Yorkshire Best	22/– to 23/–	—
Derbyshire Best Bright House	22/– to 23/–	—
Screened House Coal	19/– to 20/6	—
Best Screened Nuts	17/– to 18/–	—
Small Screened Nuts	14/6 to 15/6	—
Yorkshire Hards	16/– to 18/–	—
Derbyshire Hards	16/– to 18/–	—
Rough Slacks	8/6 to 9/6	—
Nutty Slacks	7/– to 8/6	—
Smalls	5/– to 6/–	—

Blast-furnace Coke (Inland) 12/– to 12/6 on rail at ovens
Furnace and Foundry Coke (Export), f.o.b., 18/– to 18/6

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	19/6 to 19/9
Second Smokeless Large	18/9 to 19/6
Best Dry Large	19/– to 19/6
Ordinary Dry Large	17/9 to 18/3
Best Black Vein Large	18/3 to 18/6
Western Valley Large	17/9 to 18/–
Best Eastern Valley Large	17/7½ to 17/9
Ordinary Eastern Valley Large	17/3 to 17/6
Best Steam Smalls	13/– to 13/6
Ordinary Smalls	11/– to 13/–
Washed Nuts	19/– to 25/–
No. 3 Rhondda Large	19/6 to 19/9
„ „ Smalls	15/– to 16/–
No. 2 „ Large	17/– to 17/3
„ „ Through	15/6 to 16/–
„ „ Smalls	14/– to 14/3
Foundry Coke (Export)	22/6 to 36/6
Furnace Coke (Export)	17/– to 18/–
Patent Fuel	19/– to 19/3
Pitwood (ex ship)	18/9 to 20/6
Swansea—	
Anthracite Coals:	
Best Big Vein Large	36/– to 38/6
Seconds	27/– to 32/6
Red Vein	22/6 to 27/6
Machine-made Cobbles	41/6 to 48/6
Nuts	40/– to 48/6
Beans	28/6 to 32/6
Peas	18/6 to 21/–
Breaker Duff	8/6 to 9/6
Rubbly Culm	8/3 to 8/9
Steam Coals:	
Large	20/– to 20/6
Seconds	18/– to 20/–
Smalls	11/6 to 13/–
Cargo Through	16/– to 17/6

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate; Joists (minimum), 22/6; Ordinary Ship, Bridge, and Tank Plates and Sections, 15/– if home consumers confine purchases from associated British Steel Makers. (*e*) Delivered Black Country Stations.

French Engineering Notes.

(From our own Correspondent in Paris.)

Quota Difficulties.

IMPORT quotas are dominating the commercial and industrial situation, and the protests of the British and American Chambers of Commerce in Paris, which have called upon their respective Governments to take immediate action for the protection of manufacturers trading with France, appear to have convinced the French that if a restriction of imports may be justified under present circumstances there is something wrong in the way the system is applied. Not only is it wrong, but it is almost certain to provoke reprisals which will be dangerous to French economy. The method of fixing quotas has been to allot to each country an amount in proportion to the imports during a certain period. Now it happens that the period chosen for machinery corresponds with a time of exceptional activity on the part of Germany, which sent enormous quantities of material into France on account of reparations and thus secured a standing which enabled it to expand its business by selling at prices below those of its foreign competitors. Now that British manufacturers are able to trade under normal conditions, with sterling at somewhere near the level of world values, and are consequently in a far better position to export, they are deprived of the French market because the Germans had special facilities to monopolise it. The quotas have been distributed without taking into account the changed conditions under which trade is now carried on. The French are beginning to be impressed with these anomalies by the trouble they experience with the import quotas of agricultural produce, which have had the result, in some cases, of holding up enormous quantities of perishable produce at the Customs while the country is suffering from a dearth of home supplies and exorbitant prices.

Railway Speeds.

On the 100 miles of P.L.M. line from Laroche to Dijon there is an almost continuous up gradient for 82½ miles, ranging from 1·8 mm. to 6·8 mm. per metre, the total rise in that distance being 318 m. From thence there is a winding fall to Dijon. Owing to the number of Paris-Marseilles *rapides* that travel over this section every day, the company found it necessary to avoid any irregularity of the service arising out of difficulties of acceleration after stoppages on the gradient by constructing locomotives of an exceptionally powerful type. It is now running a super-mountain type of locomotive working at a steam pressure of 285 lb. per square inch and developing 3500 horse-power. Its total weight in running order is 125 tons. In an attempt to beat the record last week the locomotive was attached to fifteen coaches, the total load of 636 tons being 123 tons more than that of the usual Paris-Marseilles *rapide*. On the run against a head wind and rain the train had to slow down three times and reduce speed on the last down gradient of 17 miles. It covered the full 100 miles in 77 minutes. Until the bridges are strengthened on the remainder of the line between Paris and Marseilles the super-mountain locomotives will only run on the Laroche-Dijon section. The super-Pacific on the Paris-Orleans Railway has given excellent results during trial runs between Aubrais and Redon, when it hauled a train of 550 tons at the maximum regulation speed of 74½ miles an hour for the full distance of 236 miles. The consumption of coal was 6870 kilos. The new locomotives will be used on the sections between Aubrais and Bordeaux and between Aubrais and Saint-Nazaire.

A Hydraulic Problem.

The main source of the river Garonne in the Pyrenees has for some time past been dwindling in volume, and this fact is alarming the inhabitants of Toulouse and other towns in the South of France to whom the supply of water is a vital necessity. The phenomenon appears to confirm a theory that the river has its origin in the Maladetta glacier on the Spanish side of the Pyrenees, though there was some hesitation in accepting that view because the watershed would seem to divert the supply to the south. In any case, the water falls into an abyss and disappears, and it is now fairly certain that it runs underground through the Aran Valley into French territory. The diminishing supply to the Garonne coincides with the operations of a Spanish company which is constructing a hydro-electric power station to utilise the energy produced by the head of water from the Maladetta glacier, and is preparing to distribute water for irrigation over the territories between the Pyrenees and the river Ebro. The carrying out of that scheme would dry up the main source of the Garonne altogether. Whether Spain has the right to cut off a water supply to a neighbouring country is a debatable point. Some other similar cases of much less importance have not yet been settled, but it is stated that the Spanish company has suspended its operations until the problem has been dealt with by the French and Spanish Governments.

Economic Tendencies.

There are three items of news which throw some light on the economic situation. The tax on turnover of 2 per cent. on the total value of goods delivered out of Customs was imposed with the idea of placing foreign manufacturers on the same footing as the French. It is now increased and called an "import tax," which changes its character. While retaining 2 per cent. for raw material the tax is raised to 4 per cent. for semi-manufactured goods and to 6 per cent. for manufactured goods, which covers rolled iron and steel. Another item of news is that the railway balance sheets show that the deficit of the six railway companies and of the State Railways for 1931 exceeds 2579 million francs, which is nearly double that for 1930. Finally, in view of the preference being shown to Germany at the expense of Great Britain in the fixing of import quotas, it is interesting to observe that while during the first two months of the year the imports from Germany amounted to 704 million francs and from Great Britain 364 million francs, the French exports to those countries were respectively 311 million francs and 434 million francs.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

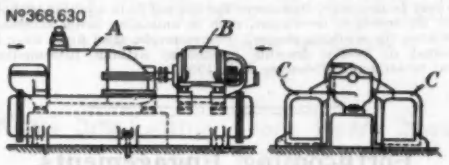
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TURBINE MACHINERY.

368,630. June 18th, 1931.—TURBINE PLANTS, Brown Boveri et Cie, Baden, Switzerland.

It is claimed that this turbo-generator unit, in comparatively small sizes, occupies a minimum of floor space. It comprises the turbine A and the generator B with the two condensers C, C,

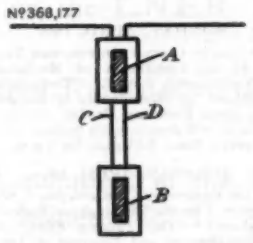


between and to which, the turbine and generator are connected. In the space below the various service pumps are arranged. Arrangements are made for the relative expansion and contraction of the several units by fixing the turbine to the condensers at the exhaust end and allowing the opposite end of the machine to slide.—*March 10th*, 1932.

DYNAMOS AND MOTORS.

368,177. July 3rd, 1931.—HIGH-TENSION ELECTRIC GENERATORS, Aktiengesellschaft Brown, Boveri et Cie., of Baden, Switzerland.

In high-tension electric power networks double-wound generators have latterly been used, which are arranged so that each half of the generator winding is connected to one network. The networks can in this way be coupled through the generators, the short-circuit kVA of the separate networks being reduced. In order to separate as far as possible the separate networks from one another it is of advantage to increase the leakage flux between the separate windings of the double-wound generator. For this purpose the windings have hitherto been embedded

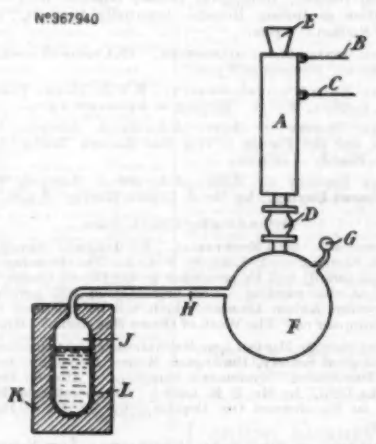


in separate slots which are arranged singly or in groups alternately around the periphery of the stator. These arrangements, however, have the disadvantage that when the machine is asymmetrically loaded magnetic asymmetries occur. When the two windings are placed in a common slot of rectangular cross section there is an insufficient inductive separation between the two windings. According to this invention, these disadvantages are overcome. The slot for receiving the two windings A and B is stamped out in the stator iron in such a manner that it has projections C D between the windings, which reduce the cross-sectional area of the slot. Owing to the projections C D, the interlinking of the stray fields of the two windings is diminished.—*March 3rd*, 1932.

SWITCHGEAR.

367,940. December 4th, 1930.—PRESSURE GAS ELECTRIC SWITCHES, International General Electric Company, Incorporated, of 120, Broadway, New York, U.S.A.

In the switch described in this specification arrangements are made for causing an arc-extinguishing gas, such as carbonic acid gas, to be blown into the region in which arcing may occur when the contacts are disengaged. A designates the pressure gas

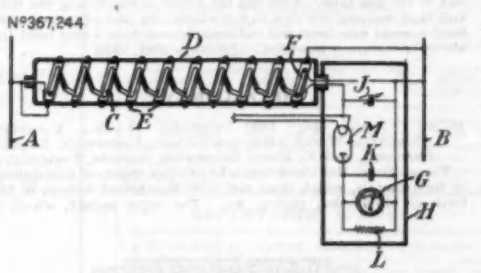


switch with the terminal connections B and C. The pressure gas is supplied to the switch through the valve D and flows away again together with the switching gases through the funnel-shaped opening E. The switch is placed above the collector F, on which a safety valve G is provided. The collector F is so dimensioned that with the operating pressure it contains sufficient gas for one or a number of disconnections and connections. It is connected through the pipe H with the accumulator J, which contains liquid as well as vapour. The accumulator J, which is constructed in the form of a flask, is surrounded by a heat insulation K. On its outer surface below the heat insulation is an electric heating body L, which, with the lowering of the pressure, may be automatically connected and with the increase of pressure above the operating pressure may be automatically disconnected. When, on the occasion of switching, by opening the valve D, gas is withdrawn from the collector F, the pressure within the collector and the accumulator falls considerably, in consequence of which vaporisation occurs whereby the liquid in the accumulator is appreciably cooled. This gives rise to a new condition of equilibrium at a lower pressure. In order to re-attain the requisite operating pressure the heater L is set into operation until the temperature within the accumulator again corresponds to the operating pressure. When, however, the pressure within the accumulator and the collector is too high, the gas is blown off by means of the relief valve G. In this way the temperature of the liquid falls, on account of vaporisation, until the equilibrium is again established. The provision of the heat insulation K prevents the accumulator from receiving heat, from the ambient atmosphere, which would produce vaporisation with consequent increase in pressure.—*March 3rd*, 1932.

MEASURING AND TESTING INSTRUMENTS.

367,244. May 1st, 1931.—MEASURING HIGH ELECTRICAL POTENTIALS, MORE PARTICULARLY IN RÖNTGEN INSTALLATIONS, Siemens und Halske Aktien-Gesellschaft, of Berlin-Siemensstadt, Germany.

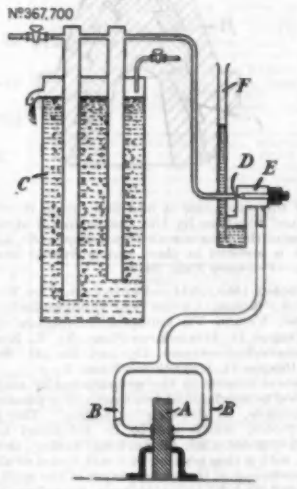
The measurement of potential by using a series resistance or potential divider offers the advantage of being able to measure high potentials with a measuring instrument of low range of measurement. The invention has for its object to overcome the possibility of the occurrence of temperature faults, and at the same time to reduce the dimensions of the resistance arrangement to small values. A and B are the high potential lines, between which the potential is to be measured. C is a potential distributor placed on the full potential, and, according to the invention, is composed of resistance elements connected in series to form a complete helical resistance, and is arranged inside a container D consisting of insulating material and filled with oil.



The resistance elements may consist of hard carbon layers applied to a glass or porcelain rod. The filling of the container D with a liquid insulating substance leads to a rapid equalisation of any differences taking place in the temperature of the resistance elements. In order to keep stray fields from the potential distributor and prevent discharge currents, the potential distributor is arranged inside a potential cage, which consists of a spiral-shaped hard-carbon strip E, applied on the container D and which is subjected to the full potential at the ends. The potential delivered to the measuring instrument is taken by the part F of the potential distributor C, and is carried to the actual measuring arrangement G fitted with its supplementary parts inside a metallic container H. A static voltmeter can be used as the measuring instrument. J and K are condensers, L a resistance, and M a rectifier. The apparatus is said to be particularly suitable for Röntgen ray work.—*February 10th*, 1932.

367,700. July 4th, 1931.—GAUGING APPARATUS, Société Anonyme pour la Construction du Matériel Automobile S.A.C.M.A., 12, rue de Lota, Paris (Seine), France.

In this gauge the measurement is determined by the flow of air passing through an annular orifice represented by the space between the specimen and the outlet for the air. In other words, the jaws of the gauge are set at a known fixed distance apart and the specimen is passed between them. Air is blown through passages in the jaws at a constant pressure and escapes through the intervening space. The loss in pressure through the leakage



is then a measure of the difference in the sizes of the specimen and the gap. In the diagram A represents the specimen and B B the jaws of the gauge. These jaws are supplied with air at a constant pressure by the spilling device C and through the needle valve D. The chamber E, beyond this valve, communicates with the manometer F. It will be seen that if the space between the specimen and the jaws of the gap is increased there will be a corresponding drop in the pressure recorded by the manometer, which is a measure of the divergence of the size of the specimen from the standard.—*February 25th*, 1932.

MACHINE TOOLS AND SHOP APPLIANCES.

367,647. February 9th, 1931.—SOCKET BOLTS, N. Phillips, "Karachi," Upton-road, Bexley Heath, Kent.

A bolt made according to this invention would consist of or comprise a standard screw bolt with nut, a conical hard member

or members, and a deformable member or members in the shape of a continuous ring. In application the bolt is inserted in the recess head first, together with the conical hard member, and the deformable member, the latter being next to the bolt head. A short piece of gas pipe or the like is next placed over the pro-

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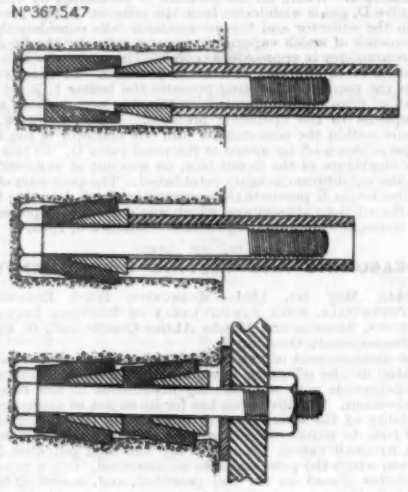

jecting portion of the bolt and pressure applied to the hard conical member by means of a few blows with a hammer on the end of the gas pipe. This has the effect of expanding the cone and thus securing the bolt in the recess. In case of two or more hard conical members and deformable members being used the above operation is repeated.—*February 25th*, 1932.

METALLURGY.

367,615. April 8th, 1931.—CASTING INGOTS, Vereinigte Aluminium-Werke Aktiengesellschaft, Lautawerk, Lausitz, Germany, and E. Roth, Lautawerk, Lausitz, Germany.

The object of this invention is to produce ingots of aluminium, or such metals, which shall not include internal defects in the form of blow-holes, piping, &c. The ingot mould, which is

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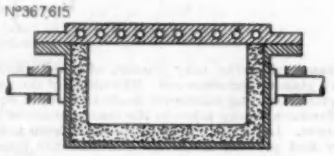

lined with a refractory and is preheated, is poured in the position shown in the sketch. The cover, which is made of copper or other good heat conductive metal, and is provided with a cooling system of passages, is then bolted in place and the mould is inverted. It is claimed that the pouring into a hot mould and the subsequent rapid cooling provides a sound ingot.—*February 25th*, 1932.

MISCELLANEOUS.

367,731. September 10th, 1931.—FUSIBLE PLUGS FOR BOILERS, E. G. Hiller and the National Boiler and General Insurance Company, Ltd., St. Mary's Parsonage, Manchester.

The object of this invention is to provide a non-corrosive protection for the fusible metal of the plug proper. The plug

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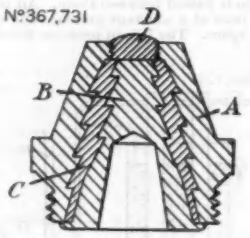

is formed by the outer case A and inner cone B, of gun-metal, which are fixed together by the fusible metal sheath C. The upper opening of the plug is sealed by a stopper D, also of fusible metal, which is screwed in place and is riveted over to ensure its tightness.—*February 25th*, 1932.

367,738. October 16th, 1931.—PREPARATION OF METAL WORK-PIECES, A. Knips, Vienna VI, Gumpendorferstrasse 15; F. Krassl, Vienna VI, Gumpendorferstrasse 15; Dr. H. Roth, Prague II, Havlickovo Nam. 3; R. Knips, Vienna VI, Gumpendorferstrasse 15, and Dr. H. Schallenberg-Krassl, Prague II, Havlickovo Nam. 3.

This invention relates to the preparation of metal which is to be subjected to mechanical treatment in a number of stages, such, for example, as drawing or rolling. The provision of metal work-pieces, which are to be subjected to stages of mechanical treatment such as drawing, rolling, deep drawing, and the like, with a thin coating of a soft metal or alloy in order to prevent hardening of the surface layer of the work-piece when being prepared, and in order to save annealing between the various stages is familiar. Thus, for example, the work-pieces for the production of drawn steel pipes, or for the drawing or rolling of steel bars or wires, after the outer surface has been cleaned by pickling, have been provided with a coating of copper, lead or various alloys of lead and tin, or the like. More than three or four operating stages, however, could not be satisfactorily carried out on a work-piece prepared in that way. If more stages were found to be necessary, intermediate annealing of the work had to be carried out if it was desired to avoid any deterioration of the work-piece. Now, the invention has for its object the preparation of work-pieces of any shape so that the treatment to which they are subsequently subjected to obtain any desired form may be effected in any number of stages without the necessity of intermediate annealing. The surface of the work-piece, after having first been freed from scale or other impurities, and prior to the application of the coating, is roughened by corrosion, this being effected by using suitable caustic means which attack the material of the work-piece. With the usual cleaning of the work-pieces to be treated special care is always taken that only the scale and other impurities are removed, the metal itself being unattacked. The pieces of work leaving the scouring bath then show a bright and smooth surface. The corrosive treatment to be carried out, in the meaning of the invention, causes roughening of the surface of the work-piece which has been previously cleaned and smoothed by the pickling process—that is to say, by allowing cavities to be formed in the surface by the action of a corrosive medium. When the surfaces of the pieces of work have been sufficiently corroded by the caustic treatment, the work-pieces are immersed in a bath of the metal to be used for coating. The coating penetrates into the cavities in the surface of the corroded work-piece, with the result that even after the first or second stage of treatment to which the work-pieces are subjected—for example, drawing or rolling—the coating metal will not be entirely stripped off. A very thin coating layer or film has been found to be specially suitable, this being obtained by maintaining the temperature of the bath so high—by using, for example, a lead-tin alloy at about 400 deg. Cent.—that the work-pieces upon being inserted and withdrawn will only be very thinly coated. At the same time the work-pieces must, of course, remain in the bath until they are at the temperature of the bath. A thin coating adheres far more firmly to the metal work-piece than a thick one. A work-piece prepared in this way may, it is claimed, be treated in as many mechanical stages as may be necessary to achieve the desired form and size without any intermediate treatment, such as annealing being necessary between the working stages. For example, steel pipes may be treated in twelve drawing operations without intermediate heat treatment.—*February 25th*, 1932.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Tuesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. "Notes on Rocket Propulsion," by Dr. Herbert Chatley. 7.30 p.m.

PHYSICAL SOCIETY.—At the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. 7. Meeting at 5 p.m.

SATURDAY, APRIL 16TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: YORKSHIRE DISTRICT.—York meeting. Assemble at the Guildhall, York, 2 p.m.

MONDAY, APRIL 18TH.

ENGINEERS' GERMAN CIRCLE (DEUTSCHER INGENIEURZIRKEL IN LONDON).—At the Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. "Technische Kulturdenkmale in Deutschland" ("Monuments of Technical Science in Germany"), by Herr Professor Dr.-Ing. E. H. C. Matschoss. Professor Matschoss will illustrate his lecture with lantern slides and a kinematograph film. 5.15 p.m. for 6 p.m.

TUESDAY, APRIL 19TH.

INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND STUDENTS' SECTION.—In the Birmingham University, Edmund-street, Birmingham. "The Talking Film," by Mr. E. A. Buckland; "The History and Progress of Arc Welding," by Mr. H. E. Knight; "The Manufacture and Application of Tapered Roller Bearings," by Mr. J. E. Spear. 7 p.m.

OLD CENTRALIANS.—Monthly luncheon at the Devereux Restaurant, Devereux-court, Strand, W.C. 2. The speaker will be the Rector, Mr. H. T. Tizard. 1 p.m.

STAFFORDSHIRE IRON AND STEEL INSTITUTE.—At the Education Offices, St. James's-road, Dudley. Annual general meeting. 7.30 p.m.

TUESDAY AND WEDNESDAY, APRIL 19TH AND 20TH.

SOCIETY OF GLASS TECHNOLOGY.—King's Head Hotel, Sheffield. Tuesday: Refractories Committee meeting, 5 p.m.; Glass Standards Committee meeting, 6 p.m.; informal dinner, 7 p.m.; Council meeting, 8.15 p.m. Wednesday: Visit to the works of the Park Gate Iron and Steel Company, Ltd., 10 a.m.; luncheon, King's Head Hotel, 12.30 p.m.; Applied Science Department, The University, St. George's-square, Sheffield, annual general meeting, 2 p.m. General meeting. "Recent Developments in Open-hearth Furnace Design," by R. A. Hacking; "A New Method of Melting Glasses and Silicates," by Dr. G. Zotos. Discussion. 2.30 p.m.

WEDNESDAY, APRIL 20TH.

INSTITUTION OF CHEMICAL ENGINEERS.—In the Rooms of the Chemical Society, Burlington House, London, W. 1. "Coal Distillation in Rotary Retorts (Internally Heated)," by Mr. Harald Nielsen. 6 p.m.

ROYAL METEOROLOGICAL SOCIETY.—49, Cromwell-road, South Kensington. Meeting at 5 p.m.

ROYAL MICROSCOPICAL SOCIETY.—B.M.A. House, Tavistock-square, London, W.C. 1. Meeting at 4 p.m. for 5 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, W.C. 2. "China and the Future of Our Far Eastern Trade," by Mr. J. O. P. Bland. 4.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, W.C. 2. "Instalment Buying," by Mr. J. Gibson Garvie. 8 p.m.

THURSDAY, APRIL 21ST.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. The Faraday Medal (eleventh award) will be presented to Sir Oliver Lodge, D.Sc., F.R.S., at this meeting. The presentation will precede the Twenty-third Kelvin Lecture, which will be delivered by Dr. W. E. Sumpner on "The Work of Oliver Heaviside." 6 p.m.

INSTITUTION OF MINING AND METALLURGY.—At the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. 1. Discussion, "Systematic Sampling of Alluvial Deposits by Banka Drill," by Mr. P. R. Lake; "Temperature of Formation of an Epi-thermal Ore Deposit," by Mr. H. C. Boydell. 5.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS: THE YORKSHIRE BRANCH.—At the Hotel Metropole, Leeds. Annual general meeting. "Tolerances and Clearances in Structural Steelwork," by Mr. J. S. Lewis. The paper will be illustrated with lantern slides. 7.15 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS: TEES-SIDE BRANCH.—In the Lecture Theatre of the Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. "Some Notes on Steel Shipbuilding," by N. M. Hunter. 7.30 p.m.

FRIDAY, APRIL 22ND.

CHEMICAL ENGINEERING GROUP.—Waldorf Hotel, Aldwych, W.C. 2. Business meeting, 6.45 p.m.; dinner, 7.30 p.m. Address, "Currency and Prices," by The Rt. Hon. Sir Robert Horne.

INSTITUTE OF FUEL.—Engineers' Club, 17, Albert-square, Manchester. North-Western Section Meeting. "Methods Employed for the Removal of Dust from Flue Gases, with Details of Operating Progress," by Mr. J. Mayer. 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, Westminster, S.W. 1. "The Film Lubrication of the Journal Bearing," by Messrs. R. O. Boswall and J. C. Brierley. 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—The dinner to celebrate the forty-eighth anniversary of the Institution's foundation will be held at the Hotel Metropole, S.W. 1.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—In the Lecture Theatre of the Mining Institute, Newcastle-on-Tyne. Presentation of Diploma of Honorary Fellowship to Mr. Summers Hunter. Declaration of result of ballot for the election of Council. Informal discussion on "The Rejuvenation of Ships and their Machinery," to be opened by Mr. Andrew Hamilton. 6 p.m.

SATURDAY, APRIL 23RD.

INSTITUTE OF BRITISH FOUNDRYMEN: JUNIOR SECTION.—In the College of Technology, Manchester. Annual general meeting. "The Merits of Oil Bonded Sands," by Mr. A. L. Key. 7 p.m.

TUESDAY, APRIL 26TH.

ILLUMINATING ENGINEERING SOCIETY.—At the House of the Royal Society of Arts, John-street, Adelphi, London, W.C. 6.30 p.m., light refreshments will be provided; 7 p.m., "Progress in Decorative Lighting," by Mr. E. H. Penwarden. Discussion.

WEDNESDAY, APRIL 27TH.

INSTITUTION OF LOCOMOTIVE ENGINEERS: BIRMINGHAM CENTRE.—In Room 178, of the Queen's Hotel, Birmingham. "The Manufacture of Copper Fire-box Plates," by Mr. W. F. Brazener. 6.45 p.m.

NEWCOMEN SOCIETY.—A General Meeting will take place simultaneously in London and New York. At the Science Museum, South Kensington, S.W. 7. "Trevithick's First Rail Locomotive," by Mr. W. W. Mason; "Early Shipbuilding in Philadelphia," by the Hon. Charles L. Chandler. 5.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, W.C. 2. "Education for Commerce," by Mr. H. Ramsbotham, M.P. 8 p.m.

THURSDAY, APRIL 28TH.

DIESEL ENGINE USERS ASSOCIATION.—Caxton Hall, Westminster, S.W. 1. "Cylinder Liner Wear," by Eng. Rear-Admiral J. Hope Harrison. 3.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—The Annual General Meeting of the Association will be held at the Chamber of Commerce, New-street, Birmingham. Annual General Meeting. 6 p.m.

SATURDAY AND SUNDAY, APRIL 30TH AND MAY 1ST.

ENGINEERING GOLFING SOCIETY.—Spring meeting at Burnham-on-Sea, Somerset. Full particulars may be obtained from the Honorary Secretary, Mr. G. H. Hopewell, Foster Wheeler, Ltd., Aldwych House, London, W.C. 2.

TUESDAY, THURSDAY, & FRIDAY, MAY 3RD, 5TH, & 6TH.

UNIVERSITY OF LONDON.—In the Department of Applied Statistics, University College, Gower-street, W.C. 1. Advanced Lectures in Statistics. Three lectures, "The *Rôle* of Statistical Method in Industrial Standardisation," by Dr. W. A. Shewhart. 5.30 p.m. each day. Admission free.

WEDNESDAY, MAY 4TH.

NATIONAL INSTITUTE OF INDUSTRIAL PSYCHOLOGY.—At the London School of Economics and Political Science, Aldwych, W.C. 2. "Psychological and Social Factors in Business Rationalisation: The Significance of Rationalisation," by Dr. Charles S. Myers. 5.30 p.m.

SATURDAY, MAY 7TH.

INSTITUTION OF ELECTRICAL ENGINEERS: METER AND INSTRUMENT SECTION.—Visit to Rugby. For details see page 379.

WEDNESDAY, MAY 11TH.

INSTITUTE OF FUEL.—Burlington House, Piccadilly, W. 1. "The Artificial Formation of Bituminous Coal and Mineral Oil Hydro-carbons," by Dr. Ernst Berl. Eight other technical societies have been invited to join this meeting. 6 p.m.

INSTITUTE OF METALS.—In the Hall of the Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Annual May Lecture, "The Plastic Deformation of Metals," by Professor F. Körber. 8 p.m.

NATIONAL INSTITUTE OF INDUSTRIAL PSYCHOLOGY.—At the London School of Economics and Political Science, Aldwych, W.C.2. "Psychological and Social Factors in Business Rationalisation: The Dangers of Rationalisation," by Dr. Charles S. Myers. 5.30 p.m.

WEDNESDAY, MAY 18TH.

NATIONAL INSTITUTE OF INDUSTRIAL PSYCHOLOGY.—At the London School of Economics and Political Science, Aldwych, W.C.2. "Psychological and Social Factors in Business Rationalisation: The Advantages of Rationalisation," by Dr. Charles S. Myers. 5.30 p.m.

WEDNESDAY, MAY 25TH.

BRITISH SCIENCE GUILD.—At the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Polar Lights," by Professor Sydney Chapman, F.R.S. 4.30 p.m.

MONDAY, MAY 30TH, TO FRIDAY, JUNE 3RD.

INSTITUTION OF ELECTRICAL ENGINEERS.—Summer meeting at the North Midland Centre. For provisional programme see page 379.

TUESDAY, JULY 5TH, TO SATURDAY, JULY 9TH.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.—Royal Show at Southampton.

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